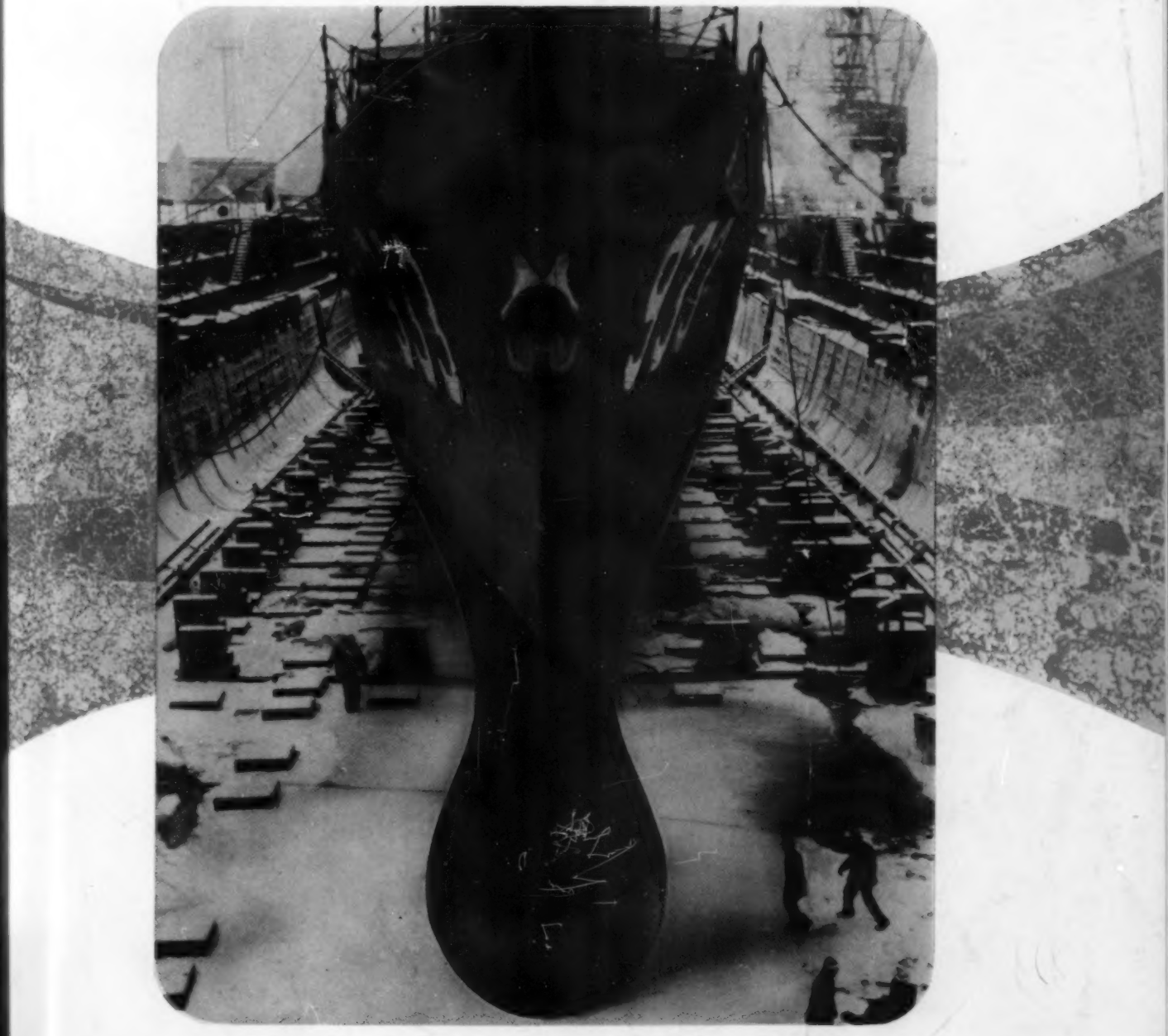
Volume 1, Number 3

underwater engineering



THE MAGAZINE OF ASW, USW AND OCEANICS

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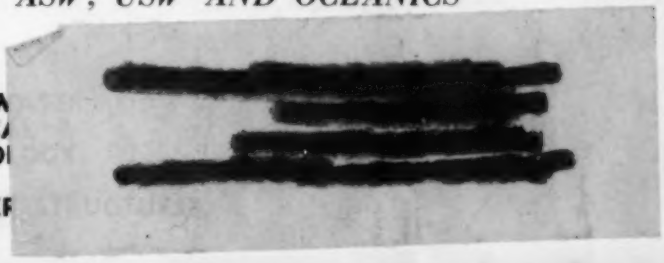

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I would like to quote something that Mr. Khrushchev stated in April 1955. "We must realize that we cannot co-exist eternally or for a long time. One of us must go to his grave. We do not want to go to the grave; they do not want to go to their grave either. So what can be done? We must push them to their grave." Now, in the Navy we build on what a famous man stated years ago when he signed the papers that began the Navy. John Adams in 1775 stated the following: "Neither nature nor art have partitioned the seas into empires. The treasures of the oceans belong to all free men. Upon this strong foundation do I build and go forward to fortify free man's rights."

Vice Admiral John T. Hayward, USN
Deputy Chief of Naval Operations
(Development)

underwater engineering

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cover

The complexity of underwater communications—covered in a series of articles in this issue beginning on page 17—is exemplified by the bow dome installation of the USS *Barry* (DD-933). Mounted in the dome is the latest type of long-range sonar. The bow dome installation will be a feature of the new ASW *Dealy* class of destroyer escorts scheduled to join the fleet in late 1963.

★ ★

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editorial ★★★★★★★★★★★★★★★★★★★★★★★★★★★★

challenge for the new administration

One of the most vital defense debates of modern times is likely to be staged in the Nation's capital as soon as the new administration goes to work. Little noticed, but at a most timely moment, the Department of Defense has put on its list of legislative matters for Congress a request for study of the possibility of equipping our allies with submarines. Many political leaders are beginning to press the issue of lending POLARIS-type submarines to NATO countries. The importance of a far-reaching submarine defense system is particularly obvious in the wake of Khrushchev's announcement of Russia's nuclear-powered submarines.

There is a no doubt that Khrushchev is correct in perceiving that he will achieve the utmost damage to the United States by undermining NATO. It is therefore only to be expected that he is trying to divide and conquer — to frighten the smaller NATO nations and to threaten the larger ones should they go too far in support of the smaller ones. It is also to be expected that our politicians and military experts will resist Khrushchev — that they will push the buildup of NATO's strength. They should be commended for this attitude.

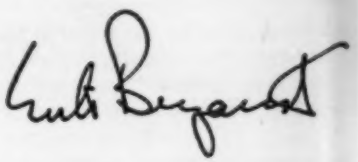
Yet, there are several disturbing and negative factors involved here. The British, who launched their first atomic submarine the day after Khrushchev told the world of his, have said they are reluctant to submit any atomic weapons to the Germans. It could well be that the British are hoping to retain European leadership in the A-sub field. If so, we cannot afford to tolerate this viewpoint. The military strength of NATO lies in an abundance of the most modern weapons. Our leaders must make certain that all NATO nations are the best equipped, while continuing to work for the political advancement of the alliance as well.

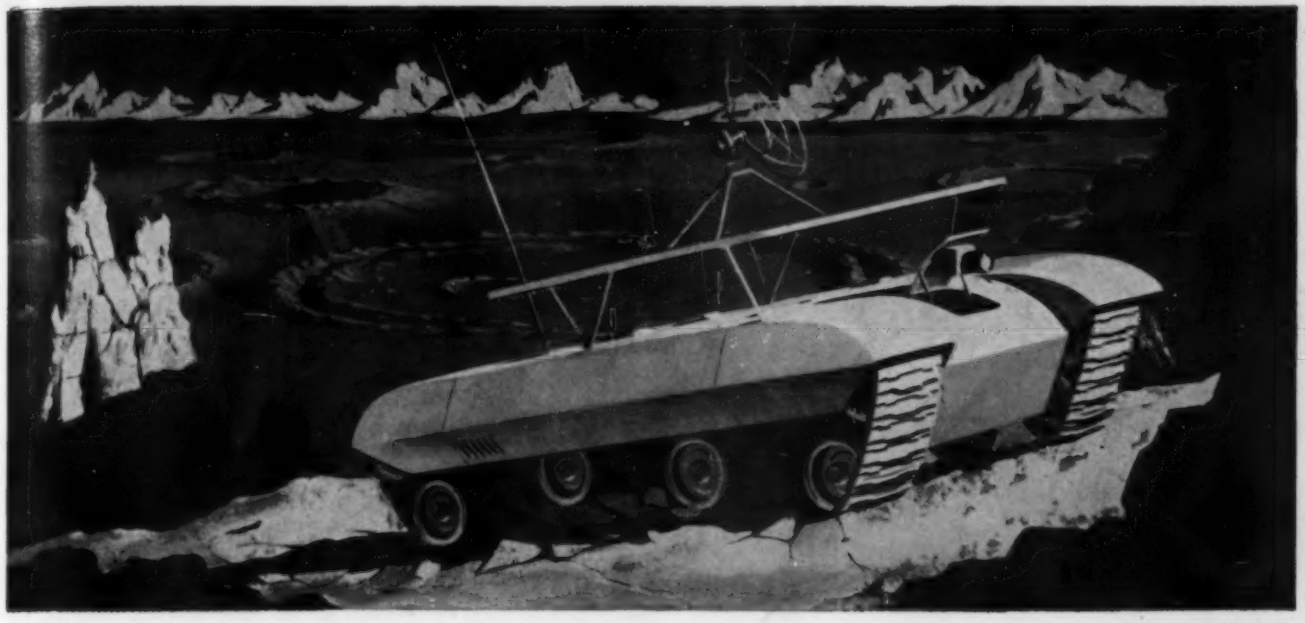
Another sad fact about a potential NATO submarine buildup is the alarmingly slow pace with which new weapons are being sent from this country to our allies. U.S servicemen returning from duty in Europe have consistently pointed out that the NATO standardization programs and the flow of equipment to the NATO forces are lagging. Some experts have hinted it may take as long as seven years for a new weapon system to be made available to NATO after it has been adopted or started here. The NATO procurement picture is blurred. There are differences of opinion among the member nations and hesitancy on our part to speed up deliveries. Without a new approach and a better sense of unity, a stepped-up atomic submarine program seems impossible or at best many years away.

The forty-four atomic submarines authorized in this country do not suffice as a deterrent against Russia, even if they are backed by strong strategic Air Force bombers and missiles. We cannot afford to cut down on their number and lend some of them to our allies. But we should plan now to step up the building program for that purpose, and conduct it in such a way that it will not take seven years to place them in NATO's hands.

In the view of many military planners, the day will come when both Russia and the NATO alliance have relatively invulnerable military forces, with less of a chance for all-out war. If we are to hope for world peace on the ground that neither side will attempt an attack so long as they fear each other's power, then we must include the most modern of weapons — the missile-firing nuclear submarines — in the allied defense structure.

One of the most vital parameters for a successful and strong NATO is that we push ahead on the basis of mutual trust. This being the case, we must get a NATO submarine program organized immediately. It can be done. Every day's delay is a dangerously wasted opportunity.





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nautical notes

By Peer Fossen

★★★★★★★★★★★★★★★★★★★

A contract for complete re-evaluation and possible rewrite of the Navy's manual of design specifications has been awarded by the Navy to a five-member venture of civil, mechanical, and electrical engineering firms. Teams from the joint venture are making preliminary studies with various BuDocks sections. The whole job will take many months.

• • •

There will be a Congressional investigation in 1961 into what Democratic Senator Hubert Humphrey believes may be waste in cancellation of over $600 million in research projects initiated by the Navy. SEA MASTER ($387 million), REGULUS ($210 million), PLATO ($14.2 million), and RAT ($15 million), were among the projects cancelled. The subcommittee wants to know the reasons for cancellation and, most importantly, how much of the Government's investment was salvaged by application of information to other systems.

• • •

Undersea fuel tanks are being tested by the Navy in the Gulf of Mexico. The U.S. Rubber Co. has built a flexible 1,200-barrel prototype under an ONR contract. Submerged 52 ft below the surface on the Gulf's seabed, the system would serve as an emergency cache for fleet ships. Full scale storage containers would be in the range of 25,000 barrels, and several would be interconnected to a common header in actual operation.

• • •

Turbulence meter for underwater use has been developed by Aerojet's ASW Division at Azusa, Calif. For the first time, it will allow direct measurement of turbulent waters.

• • •

Bathymeter, shown by Nots, can measure three important oceanographic variables: temperature, pressure, and sound velocity at great depths. The device, completely transistorized, is a frequency modulated telemetering instrument which can function at depths of seven miles. It makes possible accurate prediction of the best sound areas—a factor important to submarine defense.

• • •

Stowage problems have always hampered submariners, and none are probably more aware of this than the cooks of the long-submerged and far-traveling atomic submarines. To make certain that future submarines — especially ballistic missile submarines — have adequate amount of provisions, the Navy has developed a special hose storage system with a semi-automatic can dispenser. The new food storage device will be installed for testing and evaluation in the *Theodore Roosevelt* (SSBN 600). The device will be installed in the "lost" void space between adjacent web members in the submarine's hull. It was developed by the Food Science and Engineering Division of the Navy Supply Research and Development Facility.

• • •

To improve its support of nuclear-powered ships in the Pacific, the Navy will build a nuclear chemistry laboratory at the Pearl Harbor Naval Shipyard. A building is being remodeled as a laboratory and will be ready next year.

• • •

This is how the Navy will apply the extra $41,886,000 released by the Defense Department for antisubmarine warfare research and development programs in fiscal year 1961 (Congress actually voted an extra $50 million for ASW R&D):

Distribution and classification	$21,183,000
Weapon development	5,050,000
Oceanography research	1,453,000
Basic & applied research, test & evaluation	14,200,000

• • •

Two mothballed Navy Fleet oilers — *Chikaskia* (AO 54) and *Chipola* (AO 63) — are being put back into active service. The Maryland Shipbuilding and Drydock Co., Baltimore, Md., won a $1,431,619 contract to alter and repair the ships for activation by mid-November 1960.

LETTERS TO THE EDITOR

To The Editor:

Thank you very much for sending me a copy of Volume 1, Number 1, of Underwater Engineering.

I believe you have made a most auspicious beginning which should be welcomed by those in industry and the Navy who seek to increase our ability to utilize the oceans to the benefit of our economic and military strength.

As you advance in your publication program, you may wish to give more attention to other applications of underwater engineering including development of food supplies and natural resources, new and novel vehicles, ocean surveillance and control, etc.

Meanwhile, I congratulate you on an outstanding first issue.

John S. Coleman
Executive Secretary
National Academy of Sciences
National Research Council
Division of Physical Sciences
Washington, D.C.

Thank you for your kind words. UE will endeavor to cover all problems and developments possible for its market. Ed.

To The Editor:

I have seen your first issue of Underwater Engineering and would appreciate a copy. If you find my qualification adequate to add my name to your exclusive roster I would appreciate the gesture, as my entire group has been omitted!

Andreas B. Rechnitzer, PhD
Director, Bathyscaph Project
U.S. Naval Electronics Laboratory
San Diego, California

Welcome aboard. You certainly qualify. Ed.

To The Editor:

Several of my colleagues and I have reviewed the first issue of Underwater Engineering magazine with a great deal of interest. I am particularly favorably impressed with the general character of the publication and I am sure it will fill in an excellent manner a need which has been long felt in providing a general means of communication and interchange of ideas in underwater engineering.

I shall be reviewing the contents and organization of the material

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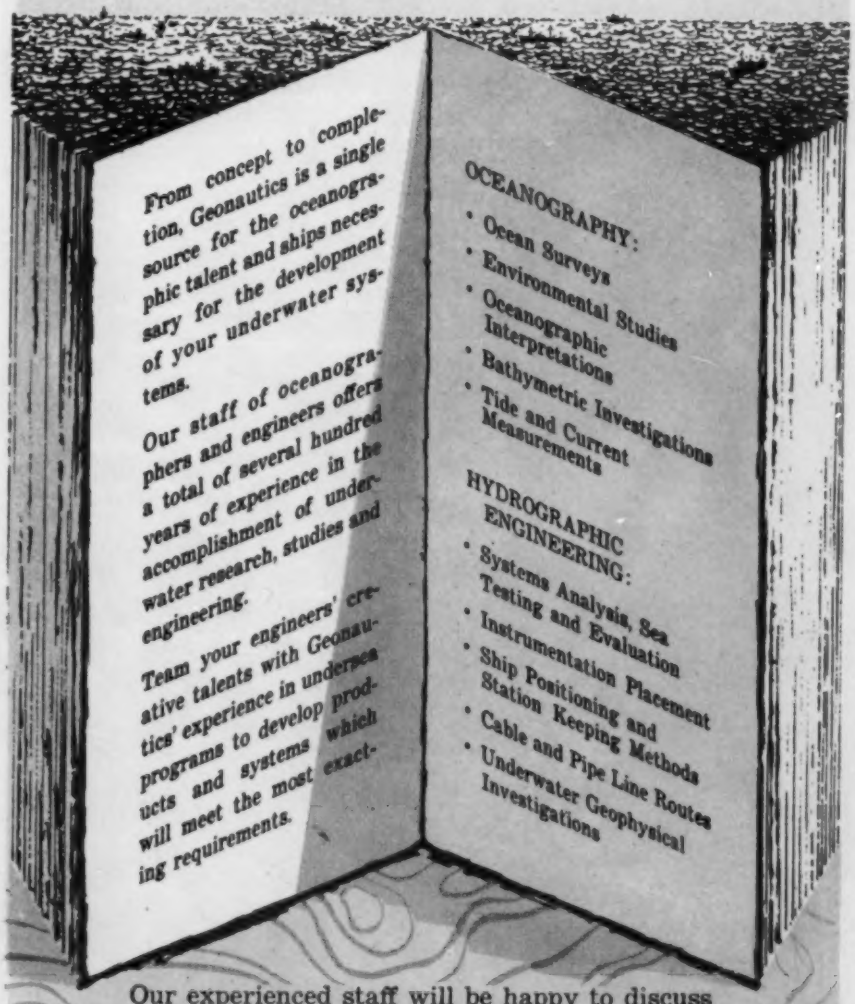
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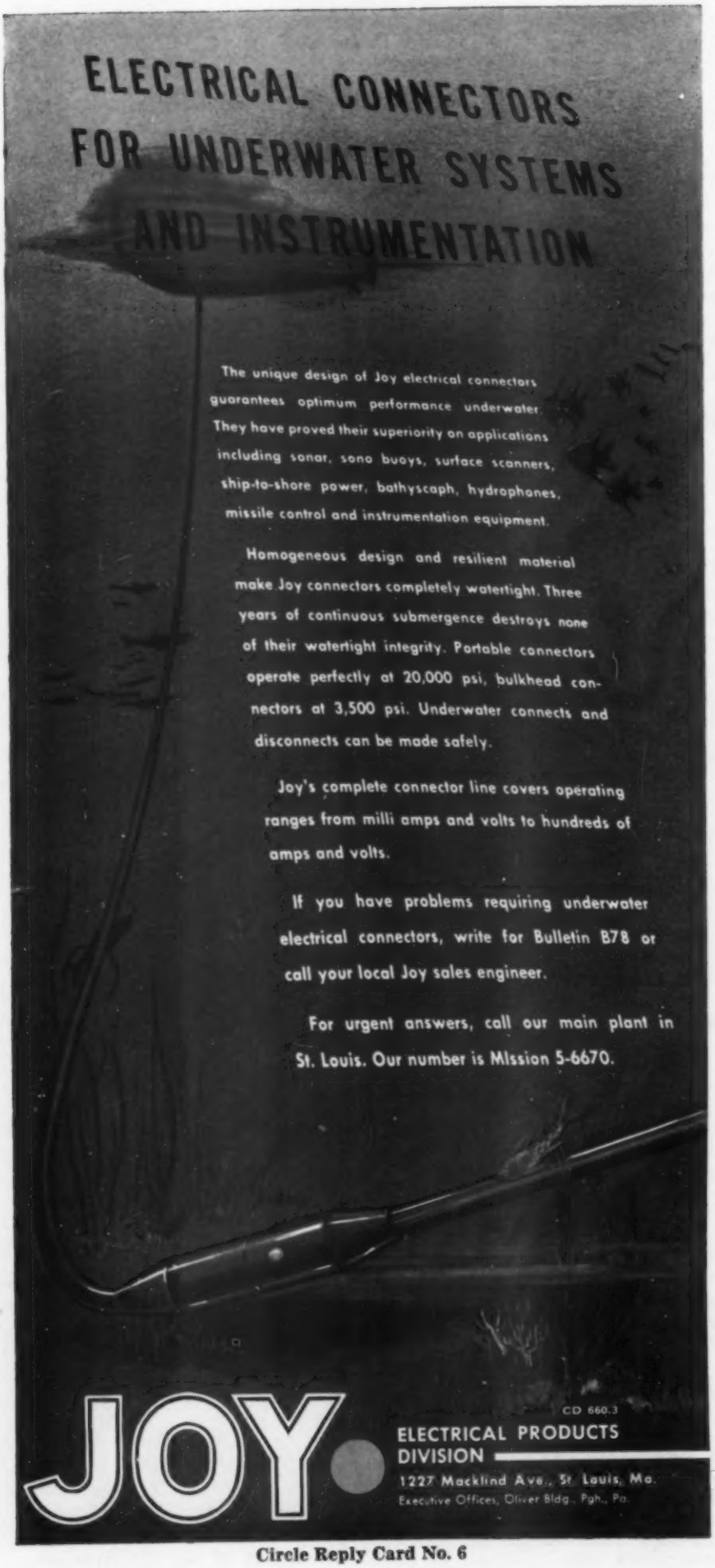
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presented in the magazine further and will write you again when my thoughts have become more mature with reference to any constructive comments that I might make.

Lorenz G. Straub, Director
University of Minnesota
Institute of Technology
Minneapolis, Minnesota

We certainly appreciate your interest and will welcome your future comments. Ed.

To The Editor:

I would like to take this opportunity to congratulate you on the quality and coverage of your first issue of Underwater Engineering. The fact that this note is somewhat belated is by no means an indication of lack of enthusiasm on my part nor that of my colleagues who have read that issue with great interest.

It is our sincere hope that your publication will continue with equal quality as it will undoubtedly become a primary means of making new developments (technically, politically, and otherwise) known to interested individuals and organizations throughout the country. It seems that the primary requirement for extensive support and effort in oceanography and underwater engineering is finally approaching realization and Underwater Engineering is and will continue to be a definite asset to this field of endeavor. I have only one question (which could be taken as my one criticism). Do you plan eventually to publish more often than on bi-monthly basis?

Paul R. Miles
Senior Research Engineer
Melpar, Inc.
Applied Science Division
Watertown, Massachusetts

Yes. Ed.

To The Editor:

The second issue of your new Publication, Underwater Engineering was excellent. I saw the first issue from a friend of mine who was connected with Bu-Ships in Washington.

I have received the second issue and if there is a copy of Volume 1, No. 1, available, I would appreciate receiving it.

I thank you in advance for any attention you give.

Robert K. Holt
Project Administrator
RD 221 Tape Recorder/Reproducer
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Your copy of Vol. 1, No. 1 is en route. Ed.

shipways

By William O. Foss

The U.S. Navy, which prides itself on having the most modern fighting fleet in the world, is plagued with a rapidly growing collection of old, worn-out, weather-beaten ships. About 78 per cent of the present active fleet was built under World War II and earlier shipbuilding programs. There are statutory age limits for the various classes of naval ships. This however, does not mean a ship becomes a pile of junk when she reaches the end of her statutory life, but it does mean she is rapidly wearing out.

Submarines are considered to be old and obsolete when they reach the age of 13; destroyers and destroyer-type ships are old at 16; carriers, cruisers and larger combatant ships are ready for the graveyard when they are 20 years old. Adding to the age trouble is the wear and tear resulting from protracted and accelerated operations which have left little time for maintenance. The ships' fighting power is impaired; their equipment is obsolescent.

The Fleet Rehabilitation and Modernization (FRAM) program was set in motion to stem the onrushing block obsolescence. In addition to the aforementioned types of ships, the FRAM program also includes amphibious craft.

* * *

In spite of new construction and FRAM, 201 ships became overage in fiscal year 1960; and 68 will join the obsolescent and old-time group in fiscal 1961. The years ahead do not look too bright, either. Come fiscal year 1962 the Navy will add another 30 ships to its overage group; 39 will be added in 1963; 50 in 1964; 82 in 1965; and 87 in 1966.

Based upon past and current shipbuilding programs, the annual input of newly completed ships into the fleet will probably not exceed 30 each year for the next ten years. Current operational plans call for an active Fleet strength of 817 ships for the next 8-10 years. From this it is easy to see that the American fleet of tomorrow is going to be an old fleet, despite the marvels of technological advances.

The rate of building new ships has been slow, hampered on all sides from the cancer of inflation and self-imposed budgetary restrictions. Unless the government and Congress learn to appreciate the seriousness of the situation and show a willingness to accept the responsibility for improving the readiness of the fleet, the U.S. Navy is going to lose out to block obsolescence.

* * *

Six new constructions are scheduled to join the active fleet during the last quarter of 1960. The active fleet strength now totals some 383 warships and 434 support and auxiliary vessels. Due to join the fleet on Nov. 9 is the *Tullibee* (SSN 597), built by the Electric Boat Div. of General Dynamics. She will be followed on November 17 by the *King* (DLG 10) at the Puget Sound Naval Shipyard.

Another POLARIS-firing submarine, the *Theodore Roosevelt* (SSBN 600), joins the active fleet on November 30. She is being built by the Mare Island Naval Shipyard. The Boston Naval Shipyard is going to be busy on December 17, when the Navy commissions two guided missile ships, the *Farragut* (DLG 6) and *Henry B. Wilson* (DDG 7). Winding up the new commission in 1960 will be the *Shark* (SSN 591). Built by the Newport News Shipbuilding and Dry Dock Co., the *Shark* will join the fleet on December 30.

* * *

The Norfolk Naval Shipyard is becoming another submarine repair yard. The yard's first submarine customer will be the *Grampus* (SS 523), which will enter the yard for battery renewal and miscellaneous repairs. The Norfolk yard is slated to begin overhauling conventional submarines in fiscal year 1962 and nuclear submarines in 1963.

* * *

The Ingalls Shipbuilding Corp., Pascagoula, Miss., already building four atomic submarines, has won a $23,404,750 Navy contract to build another nuclear-powered attack submarine. The new submarine will be essentially a repeat of the *Thresher*-class submarine which have an overall length of 274 ft and a displacement of 3250 tons.

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capital report

By Alfred J. Zaehringer

More aluminum for marine use is shaping up, according to Reynolds Metals. Incidentally, first marine use of aluminum was for ASW in 1895. Aluminum appeared at that time for torpedo boats for the Russian and French navies.

* * *

Free piston engine for ship propulsion has been demonstrated on a British craft of 12,900 deadweight tons. The engine pushed the ship to a speed of 14.58 knots with a specific fuel consumption of 0.428 lb/shp at 3,870 shp. Total propulsion machinery was 420 tons.

* * *

True speed indicator is to be developed by Edo Corp., College Point, Long Island. The $1 million contract will result in an electrical meter which will give true ship velocity over the bottom of the ocean. The device is said to be unaffected by underwater currents.

* * *

Batteries figure big in oceanographic work. For example, the *Chain*, Woods Hole research vessel, makes extensive use of batteries for silent power operations needed for seismic recorders, echosounder, and radio-telephone. The batteries aboard this ship can handle an electrical load of 7½ kw for seven to eight hours.

* * *

Marine electronics is shaping up as a big market for ASW and commercial use. For example, Columbian Bronze Corp. has formed its Columbia Hydrosonics for seagoing electronics. The firm will make sonar depth finders, radio range finders, radio telephones, and a gas "sniffer" to detect hazards in propulsion equipment.

* * *

Ultrasonic methods for prevention of marine growth have, to date, produced mixed results. Martin Co., Baltimore, reports success in utilizing ultrasonic vibrations to prevent marine growth on two 14-ft aluminum hulls. On four tests, the ultrasonic-treated hull remained clean. On the other hand, Acoustica Associates of Plainview, N.Y., tested ultrasonics on a stainless steel sonar dome submerged in Biscayne Bay, Miami. Tests indicated that the attachment of marine growth on stainless steel surfaces was not inhibited by the ultrasonic excitation in the frequency region of 26 kc at any practical intensity level.

* * *

Spectrophotometer for underwater use has been constructed and tested at the Naval Ordnance Test Station, China Lake, Calif. The device is used for direct measurement of the spectral composition of transmitted and scattered light at various ocean depths. The photometer has been tested at depths of 200 ft and results are compatible with other published data. Tests and design refinements are continuing toward the goal of eventual use at great depths.

* * *

Air turbulence over water and how it affects evaporation and wave motion is a basic research project of the University of Michigan's Institute of Science and Technology. An optical system is used. Mathematical formulae may result which will give data on molecular transfer between air and water.

* * *

Underwater weapons of the future are being evaluated at NOL, Fort Lauderdale, Fla. The proving ground for naval ordnance now has 80 people, including 11 Navy men. A water depth of 600 ft within optical range of the shore tracking ranges is an attractive feature. Underwater recovery has been made from 360-ft depths. With modifications shortly to be made, an underwater TV system can be used at 1,000-ft depths. Mines, torpedoes, and missiles are tested here.

* * *

Target boats have been received for use at Pacific Missile Range. Powered by a 900-hp B-17 aircraft engine, the flat-bottomed, 46-ft long boats can attain speeds in excess of 25 knots. The boats skim the surface like a racing hydroplane and are either radio or manually controlled.

* * *

Hydrofoil powered by a GE 1,000-hp 720 gas turbine engine has been demonstrated by Dynamic Developments, an affiliate of Grumman Aircraft Engineering Corp. The experimental model, called XCH-6, is a forerunner of a large-scale hydrofoil scheduled for launching in 1961. Speeds of up to 50 mph have been reached by the 23-ft experimental craft in runs over inland waters near the Hague and in this country. The boat has a design capability of 80 mph. The experimental model has an engine weight of only 320 pounds.

The first successful firings of the Polaris missile are dramatic evidence of the fact that this advanced weapon will become one of our nation's most formidable deterrents to aggression. For with submarines serving as mobile missile launching pads, any target on earth is within deadly striking range if retaliation becomes necessary.

The Polaris-launching submarines are splendidly fitted out not only to aim and fire and accurately guide the missile, but also to defend themselves. Advanced Sperry submarine equipment contributes to both these functions. For precise navigation there is SINS (Ship's Inertial Navigation System), automatic steering and stabilization, depth detectors, gyro-compasses, diving and maneuvering controls, instrumentation, and computers... and the NAVDAC computer which correlates all navigation data. For anti-submarine warfare the subs have Sperry torpedo fire control systems, sonar sub detection equipment, the attack periscope itself. At two special laboratories both aspects of the Polaris program are being refined and integrated: one of which simulates submarine navigation, the other the environments of the sea.

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Circle Reply Card No. 9

underwater sidelights

By E. E. Halmos, Jr.

★★★★★★★★★★★★★★★★★★★★★★★★★

Navy's Seabees (Construction Battalions) have jumped into the space age with both feet — via a Navy assignment in one case and cooperating with National Aeronautics and Space Admin. in another. The Navy assignment is "Mobile Base Recovery" — quick restoration of Naval bases that might be damaged by large scale attack, isolated nuclear weapon accidents, or natural disasters. First step will be a nationwide training program in nuclear techniques, since much present Seabee strength is in its reserve units.

* * *

The NASA assignment brings the Seabees into Project MERCURY. It involves construction of Telemetry Station No. 11, at Canton Island, which will consist of two sites embracing telemetry and control buildings, a powerhouse, roads, utilities and communications, and a housing site for tracking personnel. Construction schedule for the Navy's toughest units (75 officers and men) has been trimmed down to a few months, with materials shipped from Seabee headquarters at Port Hueneme, Calif.

* * *

There are tremendous possibilities in a recent recommendations for a $10-$12 million yearly expenditure on a maritime research program to produce "a U.S. Merchant Marine fleet of such technological superiority that it would — even with greatly reduced subsidies — be able to compete on even terms in international trade." The recommendations come from a committee of the National Academy of Sciences — National Research Council. Spending would be by the Maritime Administration.

The program calls for simplification and standardization of ship design, to cut costs of shipbuilding in U.S. yards; sponsoring of construction and operation of advanced-concept ships such as hydrofoils; greater automation and mechanization of most shipboard operations; more economic propulsion machinery; research into hull form, structures, materials, propellers and foils; interaction of the oceans and the earth's atmosphere, and the like.

* * *

In this connection, Maritime Administration has let an additional contract to a Grumman Aircraft subsidiary presently building a prototype hydrofoil ship for experimentation both by the Navy and MA. The ship now under construction will weigh about 120 tons, be capable of speeds up to 100 mph on its foils, and be equipped with so-called "surface-piercing" foils (wings) which will give it the head-on appearance of a man standing with his arms akimbo, hands on hips. These foils are believed to have considerable advantage for a commercial vessel. Specifically, they can be retracted so the vessel can maneuver in close quarters like any surface ship.

* * *

The new contract, for about $500,000, calls for development of a fully-submerged wing (one that would remain in the water for its full length at all times) and certain other characteristics. The hope is to obtain greater sustained speeds than seem practical with the surface-piercing foils.

* * *

The Navy has a big interest in hydrofoils, particularly in ASW work. Once up on their foils ("flying" is the correct term) the ships would be almost impossible targets for surface craft. The great speeds and heavy load-carrying capacities envisioned (up to 500 tons gross weight) would make them formidable antagonists for undersea craft.

* * *

Do not count Navy's Bureau of Yards and Docks out of shore-based missile work in non-Navy projects, even though it did not get into the big missile-base construction hassle involving the Corps of Engineers and the Air Force. There are strong indications that when appropriations for Fiscal Year 1962 come up in 1961 the Navy will make a strong pitch to get in on some of the construction work for the Air Force.

BUT, SIR ISAAC, WE'RE NOT GUIDING APPLES!

Until a ballistic missile is in free fall, our inertial guidance systems must be able to account for both rocket thrust and gravity. Making them this smart is a tough job, but we hit the mark so well on Thor that all of this country's long range missiles will soon be guided inertially. If you would like to help us keep pioneering new guidance systems, and have a BS, MS or PhD in Physics or Math, or an ME or EE, please contact Mr. B. M. Allen, Director of Scientific and Professional Employment, 7929 S. Howell Ave., Milwaukee 1, Wisconsin.

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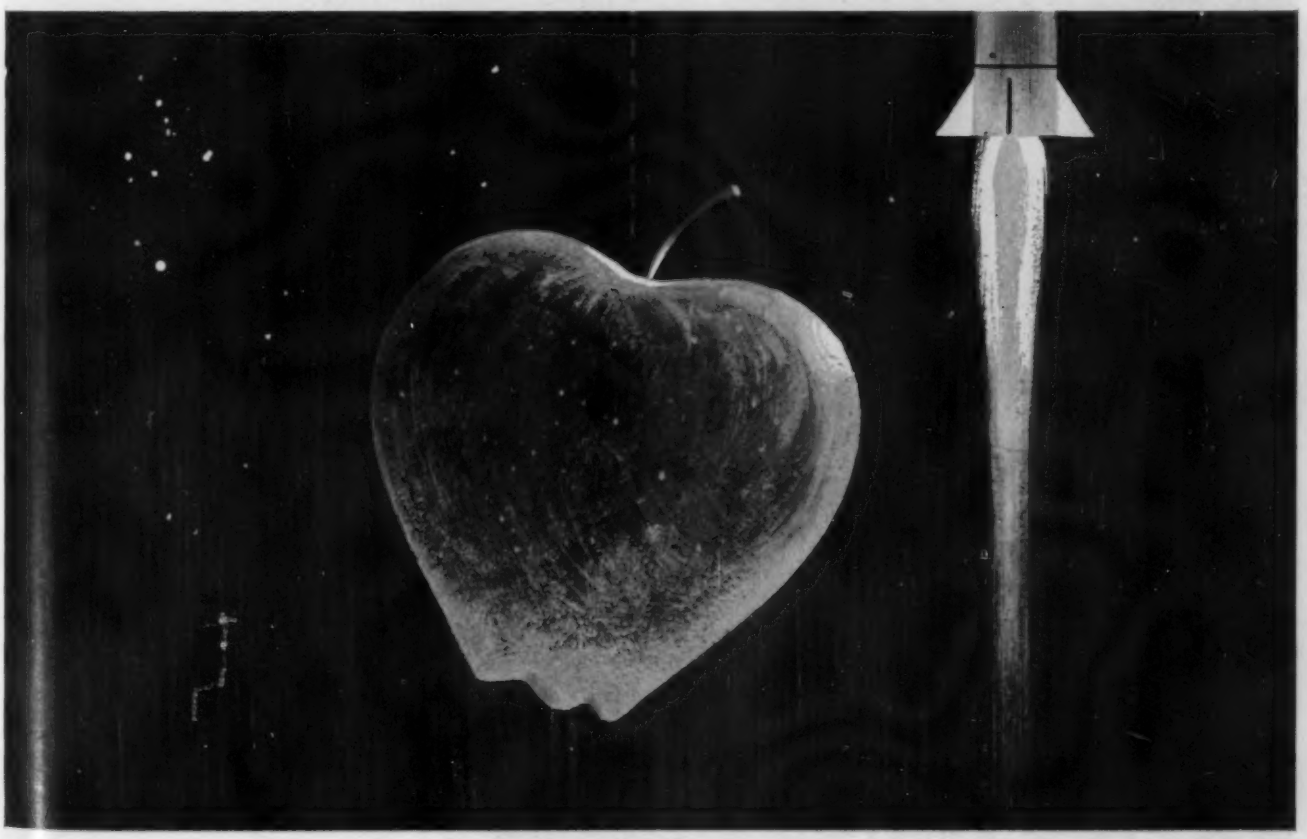

Circle Reply Card No. 10

RIGHT NOW, VITRO IS HELPING THE NAVY change torpedoes into underwater guided missiles. ■ Today, wire guided torpedoes are key ASW weapons. Wire-guidance and bearing-rider fire control are essentials in modern underwater weaponry. Both were developed at the Silver Spring Laboratory. ■ Vitro engineers were responsible for the first wire guided torpedo system and its subsequent developments. These technical specialists are now engaged in programs to apply advanced, original concepts to underwater ordnance.

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Circle Reply Card No. 11

underwater engineering

third issue Vol. 1, No. 3, 1960

underwater communication

identification is primary problem

By William O. Foss

What is underwater communication?

Ask ten different persons concerned with ASW and there will be as many answers. Some will identify underwater communication as the means submarines have to communicate with each other or with surface ships and shore stations. Others will say that underwater communication is the method for detecting, localizing, classifying, and identifying submarines. To confuse the issue further, all answers are correct. However, regardless of the interpretation, all will agree that underwater communication leaves much to be desired.

Radio communication has always posed one of the most difficult problems for submarines. Water acts as a deflecting and absorbing blanket for radio waves, thus forcing submarines either to surface or to stick an antenna above the surface to send or receive messages. This automatically jeopardizes the submarines, since they have then lost their cloak of invisibility.

With the advent of very low frequency (VLF) radio waves, however, submarine underwater communication has taken a turn for the better.

Very low frequencies of about 15 kc are particularly important to submarines because the radio signals at this wavelength can penetrate sea water. Transmissions to submerged submarines are now an everyday occurrence, but the submarines must still be close to the surface in order for their antennas to pick up the signals. Development of improved submarine antennas should improve underwater radio reception.

Communication with submarines, especially POLARIS submarines, has been subjected to an intensive study by both Navy and industry, and the first important results of these studies will bear fruit on January 1, 1961. That is the "on-the-air" target date for the Navy's and the world's most powerful radio transmitting station, built near Cutler, Washington County, Maine.

The $63-million station, with an 11,000-kw power plant, will provide very low frequency transmitting facilities, as well as the naval high frequency fleet broadcast component, to support operation of submarines and surface forces and provide special communications in the North Atlantic and Arctic areas.

The primary purpose of the Cutler station will be to communicate with FBM submarines submerged on their stations in the Arctic and North Atlantic Ocean.

With the extremely powerful transmissions from Cutler, VLF signals will penetrate the ocean at greater depths than is now possible. The exact depth range of the Cutler-transmitted signals is classified, but submarines submerged to depths of "several hundred" feet will not experience any difficulty in receiving the VLF messages. Navy is also considering establishing a similar radio station on Guam to serve Pacific-based FBM submarines.

While utilizations of the VLF por-

Research to improve underwater communication is going full steam ahead at centers like NOL's Acoustic Facility. Here chief physicist Paul Rand adjusts electronic data recording equipment.

tion of the radio spectrum is as old as the art of radio communication, new research in the VLF field may result in radio becoming one of the most promising means of detecting submerged submarines. Sonar is still today's best submarine detection device, but ASW experts have asked: "If VLF signals can penetrate turbulent water and reach submerged submarines, why not develop a submarine detection system using VLF signals?"

Navy and industry researchers are optimistic that a successful submarine detection system with VLF radio waves being extended to deep water levels will emerge from their highly classified underwater radio communication studies.

Accurate identification of a target is a real sore thumb among the multitude of ASW problems confronting the Navy. There is no sure way of knowing whether the submerged submarine is friendly or aggressive. Indentification is no problem in war. Under combat conditions we will know the locations of our own and our allies' submarines. Any stranger in the midst is automatically considered to be an enemy submarine.

Identification of submarines in peacetime, however, is difficult. Although a detected undersea craft may not be our own or belong to an allied nation, the Navy obviously cannot attack such a craft unless aggressive intent has been established. Here again radio signals — most likely in the VLF range — will play an important part in developing an effective submarine IFF (Identification: Friend or Foe) system. Navy officials indicate that some valuable progress is being made in developing a submarine sonar system, similar to the IFF system used for aircraft. While we have the means of identifying our own submarines, we are a long way from reaching the stage when ASW attack forces can distinguish between a Russian and Chinese Communist submarine.

One ASW official, whose undersea warfare experience dates back to World War II, expressed concern about achieving an effective submarine IFF system. There is the problem of knowing whether the challenged submarine actually received the IFF communication. During World War II many an American pilot was fired upon by friendly forces because the aircraft's radio failed to receive the challenging IFF signals. Such failures would virtually prohibit the use of an IFF system in anti-submarine warfare.

Adequate radio communication with submarines is of the utmost importance to the Navy. One of the current top priority Navy programs calls for installation of single sideband (SSB) equipment in submarines. SSB equipment is a godsend to submarines since it requires less space and power than comparable, conventional amplitude-modulated (AM) equipment.

The SSB radio system enables the Chief of Naval Operations, through his inner sanctum-type CNO Flag Plot headquarters in the Pentagon, to communicate directly with individual submarine skippers on station in all far corners of the globe. Among the latest SSB equipment being installed in our submarines is the Westinghouse-developed AN/WRT-2 transmitter. This long-range communication gear, specifically designed for submarine service, is the first shipboard transmitter of its capabilities sufficiently compact to be placed aboard intact through the narrow submarine hatch. The AN/WRT-2 operates at frequencies from 2 to 30 Mc/s.

Communication equipment is complicated and expensive. For communication equipment in support of the fiscal year 1961 anti-submarine warfare program, Navy is spending $2,370,200 for cryptographic aids and devices to be installed in ships and on shore stations. In addition, the Navy will spend $1,100,000 for other shore-based ASW communication equipment.

The most critical technical ASW problems continue to involve the classification and detection of deep-running, silent submarines. Intensive research is going on in this phase of underwater communication. Several years of research and development have made available improved equipment and techniques which very substantially increases the Navy's capability of detecting and locating possible enemy targets.

The Navy Security Group, for example, is spending a major portion of its research efforts in the development of high-frequency, direction-finding nets. Most of the results of this highly classified program are in direct support of the anti-submarine program. Installation of the high-frequency, direction-finding equipment, at a total estimated cost of $4.34 million, will begin in fiscal year 1962, and is expected to be completed for all stations by the end of fiscal year 1965.

Funds totalling $22.242 million were provided in the fiscal year 1961 budget to purchase electronics equipment to detect, track, and classify submarines. This budget item is intended to give the Navy 1) a device which will greatly increase the accuracy of sonar detection and localization at long ranges and 2) a modification of existing sonars to increase detection ranges approximately 30 per cent.

While Navy is spending a great deal of effort on improving acoustical detection techniques, ASW researchers are also devoting much energy aimed at developing non-acoustic detection devices. (This is no pun, but ASW people generally classify nonacoustic devices as "unsound" devices.)

The latest of these "unsound" devices is the "magnebuoy", an improved magnetic anomaly detection (MAD) device. Magnebuoys used in conjunction with sonobuoys will assure positive identification of submerged submarines by ASW aircraft. Once the aircraft has achieved target location with the sonobuoy, it will drop the magnebuoy which will definitely tell whether the target is a whale, a school of fish, or a submarine.

Present MAD-device sensitivity is quite limited, but Navy scientists state that theoretical analysis of new MAD techniques promise substantially improved ranges.

Navy is once again, after having shelved the idea for several years, investigating radar as an effective means of snorkel detection. Intelligence sources apparently have convinced ASW researchers that Soviet snorkel submarines will be around for some time to come, despite Russian atomic submarine announcements.

Navy scientists also foresee new detection devices being developed from research of microscopic and macroscopic surface effects produced by transiting submarines. A submarine puts a great deal of horsepower into the water, some of which is dissipated through turbulence and some —to a lesser but still significant degree — through generation of acoustical noises — a passing submarine also creates a rise of the surface of the ocean directly above it. Studies of these effects on the surface may bring about new photographic and infrared submarine detection techniques.

Regardless how underwater communication is defined, there is a great need to improve our anti-submarine warfare communication equipment. But, as one ASW expert explained it, before effective improvements can be realized, we must known more about the medium in which we will use the equipment, and that leads right back to more unglamorous, basic oceanographic research.★

underwater sound: its importance

future subs will depend on it for communication and detection, but will muffle it for concealment.

By Alfred J. Zaehringer

The first concrete results in the study of underwater sound, a relatively new science, occurred in 1827 when Colladon and Strum made direct measurements at Lake Geneva, Switz., over a nine mile-course. Their findings measured the velocity of sound in fresh water to be 4,708 ft/sec. (The velocity of sound in air averages about 1,087 ft/sec. in dry air at 32 degrees F.)

Thus, water is a much better sound conductor than air, and sea water has been demonstrated to be a better sound conductor than fresh water. Recent electrical recording instruments give sea water velocity as 4,955 ft/sec. (35 per mill salinity at 63 degrees F.). Studies also show the velocity varies with temperature, depth and salinity.

The standard sea sound velocity is 4,742 ft/sec. at 32 degrees F, one atmosphere pressure, and a salinity of 35 g/kg sea water. Velocity increases with temperature at a variable rate: a temperature change of 20 degrees F is common, at least in the upper layers of the ocean. A salinity increase of one part per thousand increases the sound velocity by 4.27 ft/sec. Except at shallow levels, and at the mouths of large rivers, salinity is relatively constant and can often be neglected. Depth, on the other hand, must be taken into account. For every 100 ft of depth, the velocity increases 1.82 ft/sec. The most striking depth/velocity relationships occur in the first 180 ft. At great depths, temperature and salinity effects drop out and pressure largely determines sound speeds. At 10,000-ft depth, the velocity of sound is about 4,900 ft/sec.

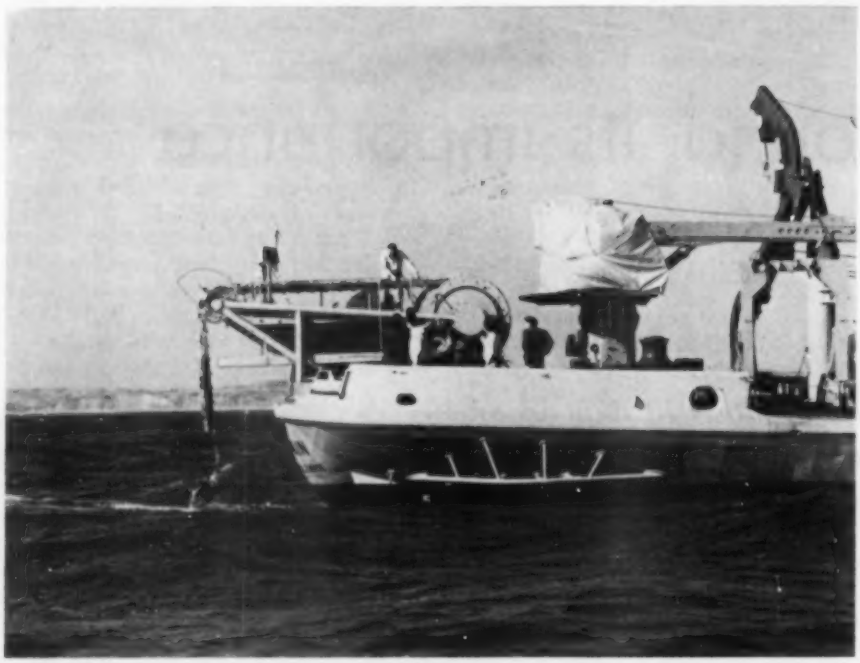
The bathythermograph is a rugged device to determine sea temperatures, from which velocity can be

Table 1

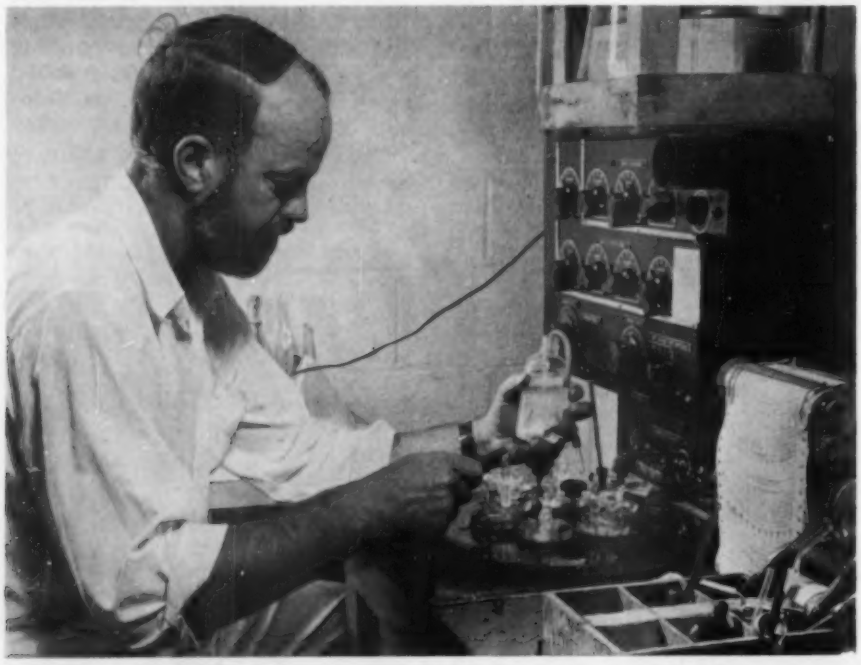
Spectrum Levels of Noise

Source	Level Range (db)
Ambient Noise	
Biological noise	
Croakers	—20
Snapping shrimp	—20
Sea noise	—74 to —54
Self-Noise	
Circuit noise	—104 to —94
DD or DE, 10-20 kc	—65 to —35
Submarine self-noise	—72 to —46
Target Noise	
Battleship	27
Cruiser	20
Destroyer	15
Passenger vessel	13
Submarine, 6-knot periscope depth, 12 knot surface	8
Corvette	8
Freighter	3

Nansen bottle (for water sampling) and reversing thermometers being readied for lowering into ocean.



Actual tests at sea and work in the laboratory go hand in hand. Here a thermistor chain for continuous electronic temperature profiling is lowered from the stern of Woods Hole's research vessel R. V. Chain. . .



. . . while in the laboratory, C. D. Densmore working at the salinometer, is preparing to fill a cell with water samples to be tested.

determined. The U.S. Navy Radio and Sound Laboratory has developed a direct sound velocity device which unlike the bathythermograph (which requires time to come to temperature), can detect small changes occurring in a few feet of water.

Energy — Sound, unlike light, needs a transmitting medium. Air and water are common media. Sound, like light, can be analyzed or broken down into a spectrum of various frequencies. Since sound can be looked on as an energy exchange or transfer, an important aspect of sound in undersea work is the energy content or intensity. Other features of interest in underwater work are: 1) energy density, 2) energy flow, and 3) sound level. Since water pressure (p) is easy to measure, the intensity (I) of sound in water is given by:

$$I = p^2$$

and the units are dynes^2/cm^4. Sound intensities are given in the decibel system where the pressure level (L) of sound, in decibels, is given by:

$$L = 10 \log I = 20 \log p$$

where the base ten logs are used. For underwater work, the standard is dyne/cm^2. Thus 20 db is 10 dynes/cm^2; 40 db is 10^2 dynes/cm^2; 60 db is 10^4 dynes/cm^2 and so on to 120 db is equal to 10^6 dynes/cm^2 (or a little over one atmosphere of pressure or about one watt/cm^2).

From small sources, the sound pulses spread out spherically, and may be calculated by the inverse square law. A large source, however, does not radiate sound energy equally in all directions. The ratio of intensities at two remote points on a straight line running through the source can be obtained by use of the inverse square law.

Losses — Since the ocean is not infinite, has a varying bottom, a varying surface, and varying composition, the transmission of sound also varies. Other factors causing transmission anomalies are: 1) directivity of beams, 2) refraction, 3) absorption, and 4) scattering. For example, with a 70-db transmission loss on a certain sonar, it should be possible to detect a submarine at 3,000 yards range; however, the detection range is more likely to be 1,250 yards in actual practice.

Explosions — Explosions, involving the sudden creation of a relatively small bubble of gas at very high temperatures and pressures, have had extensive use in underwater sound work. The pressure of the explosion is transmitted to the water and creates a strong shock wave. A relatively weak explosion can be heard at very great distances: Woods Hole Oceanographic Institute, has experimented with underwater explosions and reported the detection of a blasting cap at a distance of 75 miles and one half-pound of TNT at over 800 miles! Moreover, sound "rays" can be discerned. Sinusoidal rays do not reach the surface or bottom and are called SC (sound channel). RSR rays are those reflected at the surface but refracted upwards before reaching the bottom. R rays are reflected at both the surface and the bottom.

Supersonics—More recently, transmission of underwater sounds has been studied in the frequency and intensity range of interest to echo ranging. Some of the conclusions reached from supersonic sound work via the hydrophone are: 1) transmission depends to a large degree on the depth at which the first appreciable temperature change occurs; 2)transmission from a surface vessel with directional projector depends

Table 3

Submarine Sounds

Source	Overall Noise, db (best practices to maximum permissible limit)
Bow Plane (Hand)	15-30
Bow Plane (Power)	32-42
Steering	13-23
Drain Pump	18-32
Periscope	12-27
Trim Pump	17-35
Stern Planes (Hand)	16-29
Stern Planes (Power)	32-44
Starboard Astern Port Ahead (40 rpm)	30-42
Starboard Ahead Port Astern (40 rpm)	30-42

Table 2

Wake Strengths of Submarines

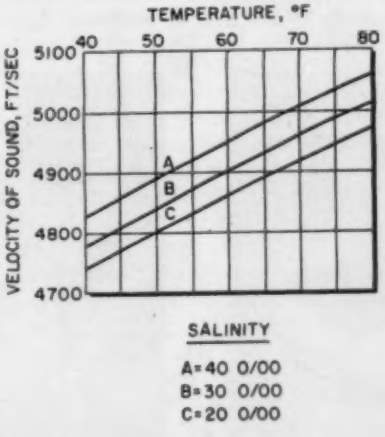
Sub Type	Depth (ft)	Frequency (kc)	Submerged Wake Strength, 6 knots (db)	Surfaced Wake Strength, 9 knots (db)
S	90	60	—26	—18
S	90	45	—24	—13
Fleet	90	45	—20	—13
S	45	45	—33	....
S	45	20	—20	....

on the depth of the hydrophone receiving the sound; and 3) the depth of sharp thermoclines influences transmission.

Echoes — Echoes, or reverberations, existing with sound pulses in the sea, are caused by some of the irregularities already mentioned. As a result, there can be scattering in all directions. This scattering can be picked up by a transducer and heard over a sonar loudspeaker. Reverberations have a definite pitch. Noise has a wide band of frequencies, however. Long (about 200 millisec.) pings of constant frequency give rise to echoes with musical-like sounds. Shorter pings give rough and grating sounds. With FM signal, the reverberation sounds like coal sliding down a chute. The pitch of the reverberation from a constant frequency ping depends on the speed of the echo-ranging vessel and the relative bearing of the projector. Echo-ranging, using reverberations, may be used to give the ranges of target vessels or to determine ocean depths. In echo-ranging, a sound signal is projected into the water in hopes that it will hit a target and be reflected back to the transmitter. Knowing the velocity of sound in the water and the time interval between signal emission and detection of the target, one can obtain the distance or range. The echo can also give size, speed, and direction of the target. This is analogous to radar.

Two main types of projectors are used: magnetostriction oscillator and the piezoelectric effect. Some of the frequencies used by the Navy are: 15, 20, 22, 24, 25, and 30 kc resonant frequencies. Source levels are around 33 to 85 db. Typical target strengths of subs at various aspects are 1) Fleet 10 db bow, 18 db stern, and 27 db abeam; and 2) S-Class sub: six db bow, seven db stern, and 15 db abeam. These tests were made at San Diego with 30-millisec. signals at 24 kc.

Background noise comes from ambient sources (rain, surf, biological, traffic, and the sea itself), it may be self-noise of the ship, or may originate at the target. Target noises are wanted in detection but not in echo-ranging, because echoes may not give accurate determinations of target range. Other noises are reverberation caused by surface and bottom irregularities, plus presently unknown scattering mechanisms. Table 1 gives amplified noise (at 24 kc) of various sources.



Velocity of sound versus temperature and salinity.

Wakes — The acoustical properties of the violent disturbances of surface waves spreading out behind a ship have been studied with sonar. The wakes return echoes but at the same time reduce their intensity. Table 2 gives typical wake strengths of submerged and surface submarines.

Acoustical Output — In outputs, one is faced with detection probabilities, inherent thresholds, and responses. However, to pick up submarines, one must know their noise levels. Table 3 gives the various sources of sound aboard a submarine and their levels. At periscope depth, overall submarine sounds are at about the 70-db level. It may, however, be down to 40 db when under evasive conditions.

At a range of less than a few hundred yards, transmission losses are highly variable and increase rapidly out to 1,000-2,000 yards. High frequencies have less loss at this range than lower ones. Reflection of bottom sounds are dominant to 10,000 to 20,000 yards. Thus, sonic listening devices are capable of detection at ranges of 15,000 yards under favorable conditions.

In supersonic listening, heterodyning is used, and there is no one frequency of sound that is more audible than another.

The reduction of sound output has long been of utmost importance in the U.S. Navy submarine program. (No such program is evident in connection with surface vessels.) It may be possible to reduce noise levels, but it may never be possible to reduce the noise level below ambient. However, the possibility of hardware operating on negative values of recognition differentials should not be overlooked. A small reduction in source level makes a big difference in the range an enemy can detect.

Future submarines will probably rely more and more on listening for detection and fire control. The aim for underwater silence is difficult but essential.★

References:

1. "Principles and Applications of Underwater Sounds," U.S. Department of Commerce, Office of Technical Services, PB 161682.
2. "Recognition of Underwater Sounds," U. S. Department of Commerce, Office of Technical Services, PB 145086.

sonar: past, present and future

By Paul Skitski

Submarine Signal Operations
Equipment Div., Raytheon Co.

One of the most marked advances in underwater technology since World War II has been in sonar systems. The simple systems of 15 years ago, employing few vacuum tubes, have grown into highly complex, transistorized, automated packages. And the systems will become more automated and complex as underwater warfare becomes more important to the nation's defense.

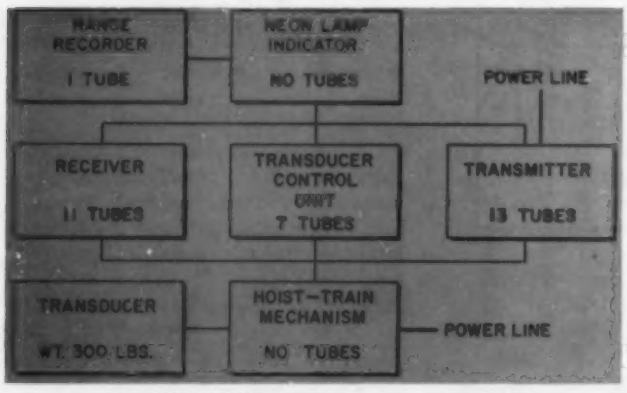
WW II Echo-Ranging — During World War II, relatively simple sonar systems were employed for echo-ranging operations. In general, a system consisted of a searchlight transducer 19 in. in diameter, a hoist-train mechanism for lowering and directing the transducer, a control system for powering the rotation of the transducer, a transmitter, a receiver, an indicator, and a range recorder. The operating frequencies used were in the neighborhood of 14 to 40 kc. The power output of the transmitter was usually less than 800 watts.

The electronic simplicity of these equipments is readily illustrated by the small number of vacuum tubes employed in a typical system. Most of these tubes were in the receiving and transmitting circuits. The cathode-ray tube, as the primary indicating device, did not get into significant use until after World War II although it was used as an auxiliary device for bearing deviation indication (BDI) on some installations. These early echo-ranging equipments provided for search in azimuth only. Transducer beamwidths ranged from 15 to 30 degrees.

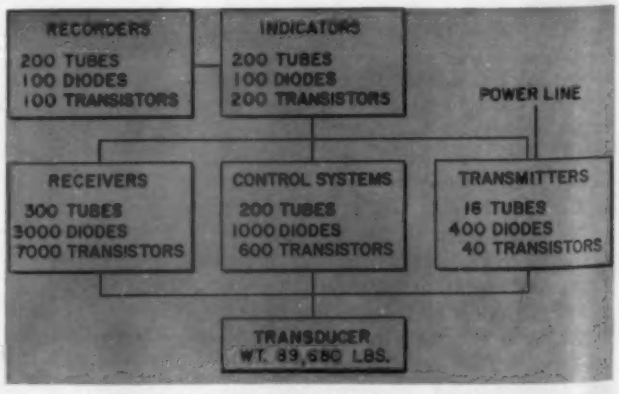
WW II Listening — Passive listening equipment of World War II vintage employed a rotating transducer or single baffled hydrophone as the acoustic detection device. The remainder of the system consisted of training mechanism for directing the hydrophone, a control system for powering the mechanism, and an audio amplifier with filters. Target data were presented to the operator aurally by headphones and visually on a BDI (meter type).

The principal feature of these early echo-ranging and listening equipments was simplicity and with it an extremely high degree of reliability. The major shortcomings were: 1) complete dependence upon the operator for effective detection and tracking operations, and 2) the lack of an integrated display system. The number of enemy submarine sinkings credited to sonar-equipped vessels shows that dependence upon the sonar operator was not a misplaced trust.

Scanning Sonar — Developments in the early postwar period centered primarily about the further development of scanning sonar systems, the initial design of which was accomplished by the Harvard Underwater Sound Laboratory just before the end of the war. Scanning sonar utilizes an upright cylindrical transducer of many elements, with the transducer permanently affixed to the hull. During the transmission of the acoustic pulse the transducer elements are connected together and the pulse is radiated over the entire azimuth. During reception, a high-speed commutation device (electronic or electro-mechanical) is used to rotate a receiving beam rapidly throughout the entire azimuth. The output of this commutator is used to generate the plan-position indicator (PPI) display on a cathode-ray tube. A slow-speed commutator, manually operated through a servo system, is used to position a receiving beam on any target displayed on the PPI. The output of this commutator is amplified and presented aurally on headphones or visually on a range recorder. Target bearing is transmitted as a synchro order



Typical World War II echo-ranging system.



Typical combination system of today.

from the slow-speed commutator.

Scanning sonar greatly improves search coverage because after each transmitted pulse the entire horizon is scanned at a rapid rate. This means that scanning sonar, in the same interval it takes a searchlight system to cover one beamwidth, searches the entire azimuth and presents the results on an integrated display (PPI). While this display is still somewhat dependent upon the operator, it generally enables an independent observer to see what the target situation is at a glance.

Scanning sonar brought the cathode-ray tube into prominent use. The number of vacuum tubes in scanning systems went up substantially over the numbers used in the early searchlight systems. A typical scanning sonar system uses between 100 and 200 vacuum tubes. A large percentage of these are associated with the timing, blanking sweep, and deflection circuits to operate the cathode-ray tube. A fair percentage of the tubes are used in the transmitting circuits because the power output had to be increased by a substantial factor to make up for the loss of directed transmission.

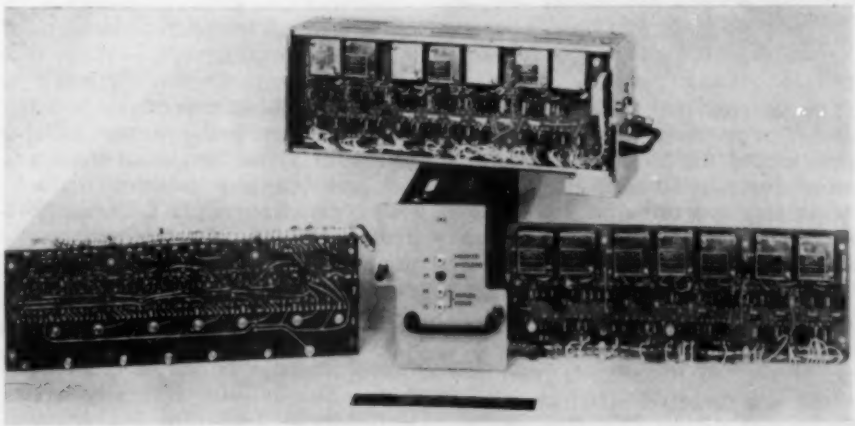
The future of scanning sonar seems certain. It is being improved steadily. Current systems are designed to perform *search*, *track*, and *attack* functions. Target information is processed by automatic or semi-automatic methods and transmitted directly to the weapon fire control system, a significant advance over World War II sonar.

Listening Equipment — Passive sonar development after World War II consisted first of refinements to the simple systems used during the war, primarily modernization of circuitry and acoustic characteristics. This was followed by the development of cylindrical arrays of hydrophones and the use of scanning techniques to provide 360-degree search coverage. In general, a high-speed commutator is used to operate a bearing-vs-time recorder for an integrated display of the azimuth, while a slow-speed commutator is used to follow a specific target. A real advance in the post-war period was achieved through the use of automatic target following (ATF) techniques. This enables the operator to "lock on" to a noise-producing target, after which the system holds the target irrespective of target or own ship maneuvering. Target-bearing information for fire-control purposes is, of course, readily available under these conditions.

Obvious improvements to be made in listening systems lie in the areas of larger arrays and improved signal-processing techniques.

Combination Systems — The need for highly accurate range and bearing data from active systems for fire-control purposes, led to the development of attack sonar equipments for use on destroyers and other surface vessels. The early equipments of this type employed servo-controlled searchlight transducers with refinements to provide high accuracy as well as capability of following the target in depression.

The complexity of the receiving and indicating components increased markedly over simple searchlight equipment and is illustrated by the fact that a typical system of this type employed approximately 400 vacuum tubes. Signal processing techniques made use of reciprocal pulse-length selectivity and auto-correlation.



Components of modern sonar systems.

Weapon advances, space and weight consideration, coupled with a desire to avoid the use of a second dome structure underneath the vessel, led to the combination of search and attack functions in single systems of the scanning type. The trend toward such combination systems is continuing and is exemplified by current designs. For example, one system currently being produced includes *search*, *track*, *classification*, *attack*, and *communication* capabilities. It makes use of more than 10,000 transistors, vacuum tubes, and diodes to perform many complex functions. Reciprocal pulse-length selectivity, auto-correlation, and cross-correlation techniques are used to obtain maximum detection capability.

Airborne Sonar — One of the most significant developments in sonar during the past twenty years has been the application of sonar to aircraft. This has been achieved through the use of sonobuoys, helicopter-dipped sonar, and lighter-than-air (LTA) airship-towed sonar. The importance of airborne sonar is readily acknowledged when the ever-increasing speed capability of the submarine is considered. Helicopters, equipped with dipped sonar, can operate singly or jointly to constitute a highly mobile force capable of searching an extensive area. The LTA airship has good endurance and is well-suited for patrol action with its towed sonar. Sonar designed for airborne use must be efficient as excess power capability is not generally available. Additionally, it must be designed to minimize weight and space requirements. These three factors — power, weight and space — pose many interesting problems for the designer of airborne sonar systems.

Complex Functions — The complexity of a sonar system is intimately related with the number of functions the system must perform and the accuracies to which their function must be carried out. Modern systems are based on demands for increased detection ranges and better target data. Much progress has been made as a result of several development "breakthroughs", but it must be recognized that the sonar of today would not be practical if modern components and manufacturing techniques such as transistors, modular construction, and printed circuits were not available.

It is to be expected that bigger and better sonars will be required in the future, and that further automation will be a necessity. Such automation is needed for two reasons: 1) to make it possible to operate the equipment with a minimum number of skilled operators, and 2) to eliminate, in-so-far as practicable, human error in the output of the system.★

big splash for polaris radome

The development of a POLARIS submarine radome strong enough to withstand the fierce smashing of heavy seas has led to the construction of an engineering facility which can prove the structural integrity of other underwater equipment.

Designed and constructed by Allied Research Associates in an abandoned granite quarry near Gloucester, Mass., the installation is comprised of a large boom affixed near the base of a sheer cliff. The object to be tested is attached near the top of the boom and then allowed to fall freely from various heights to impact the water in the quarry pit at predetermined levels. A direct wire instrumentation system records the necessary data for structural dynamic measurements.

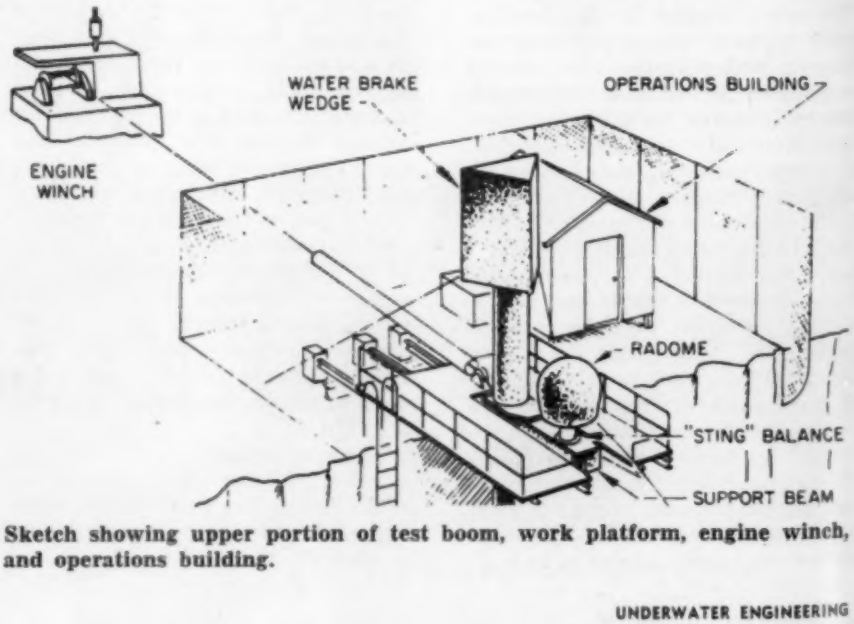
Items more adaptable to testing by the new method include other submarine radomes, submarine and communication antennas, shipboard bubbles located on the waterline, capsules, recovery systems, and launching systems. The facility could also contribute to the development of ejection seats, sonar transducers and housings, torpedoes, and even particular elements of hull design.

Operation — The seven basic elements of the system are: the boom, a hinge, a support beam, a "sting" balance, a water brake wedge, an engine winch, and instrumentation recording equipment. The boom is attached at its base to a hinge bolted to the granite quarry face nine feet above the water surface. The free end is capped by a triangular water brake wedge which both adds to the inertia of the system and decreases its velocity after water penetration. This brake, together with the natural buoyancy of the structure, assures complete arrest of the boom within 25 ft of the water surface.

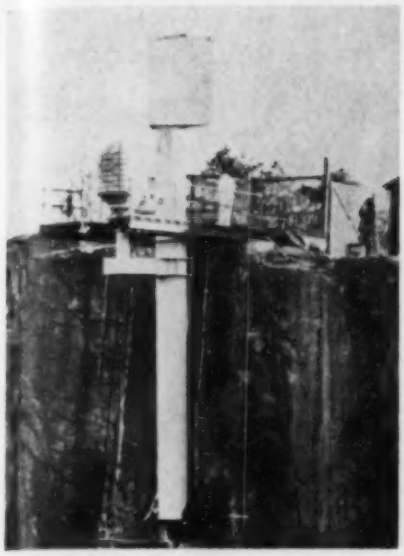
The test object is attached to a "sting" balance bolted to a support beam. This in turn is cantilevered to the boom. Recording instruments are located in a small building nearby with instrumentation on the test structure feeding directly through the boom. Data coverage is supplemented by underwater motion pictures. Quarry water depth at the impact point is 40 ft — sufficient to assure that reflectivity will not influence the test results.

To perform an impact test, the radome is attached to the boom which then is allowed to fall freely into the quarry water from a given height. Water impact at each sea state can be approximated by varying the height of fall. The present facility provides for full simulation of conditions up to sea state five.

During water penetration, 95 per cent of the radome velocity at initial impact is retained. After water penetration of the object being tested, the water wedge brake action and the boom buoyancy combine to arrest penetration of the test



Sketch showing upper portion of test boom, work platform, engine winch, and operations building.



The boom is shown in an upright position with the test radome attached.

Here the boom has been precisely set at the desired height.

object well short of the quarry bottom. Both at impact and during penetration, a continuous oscillographic record of test data is obtained, and underwater motion pictures are taken. After each test, the boom is raised by the winch motor to the position for the next drop.

Construction — Allied Research Associates — a Boeing subsidiary — undertook development of the quarry installation in response to a request from Northrop Corp.'s Nortronics Div. for a better method to conduct water impact structural and load deflection tests on radomes used to house the radiometric sextant on FBM submarines.

Features influencing the selection of Nelson's Quarry included a shear granite face of high structural integrity which rose 34 ft above water surface, a water depth well in excess of the required 25 ft, and a plateau-like surface adjacent to the top edge of the cliff suitable for the establishment of an instrumentation and data-recording laboratory.

Before final selection of the site was made, a test boring core 1½ in. in diameter and eight ft deep was taken from the face of the cliff to substantiate the integrity of the granite. This was examined by a qualified geologist who reported no seams present, no evidence of planes of weakness, and granite of better than average quality.

The water impact testing facility, as presently constituted, is designed for a radome weighing 1,000 pounds. Allied Research scientists state, however, that minor modifications to the rig will make possible the testing of larger and heavier devices. Alterations to the water brake are all that are needed to provide for a full range of impact and post impact dynamic loadings.

Specifications and capacities of the present facility are:

- Length of fixed boom: 46 ft
- Boom diameter: 3 ft
- Total structure weight: 17,000 lbs
- Max. impact velocity: 43 ft/sec.
- Maintenance of impact velocity after penetration: 95 per cent
- Theoretical max. impact force: 60,000 pounds
- Max. winch capacity: 15 tons
- Available water depth: 40 ft.

Instrumentation — In order that structural response of the test object may be documented fully, instrumentation is provided to measure deflection, strain, hydrodynamic forces and pressures, velocity at impact and radome internal pressure. Fifty-six data-recording channels are supplied. Of these, three channels measure the forces on the boom and 53 channels measure the response of the device under test.

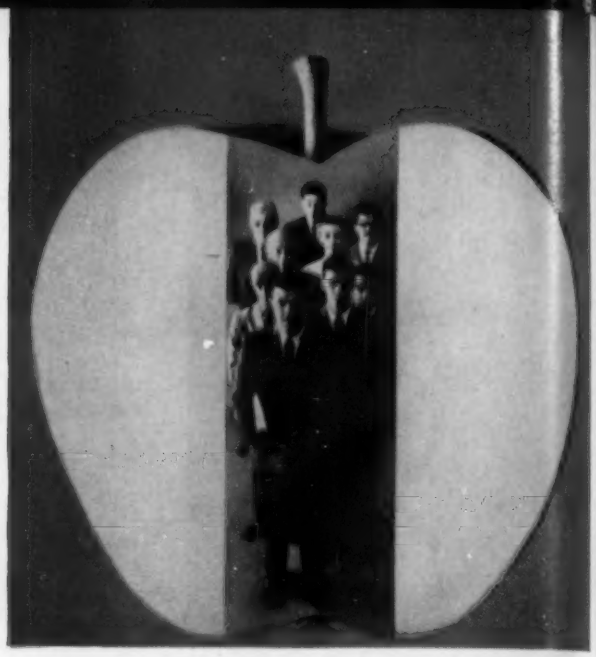
During tests of the Nortronics radome, 22 channels were used for radome strain data, 12 for deflection measurements, 12 for external pressure measurements, five for hydrodynamic force data, one for recording internal pressure data, and one to record angular displacement. Three multi-channel oscillographs measure and record simultaneously the 56 response information channels. Two of these are operated at a paper speed of 120 in./sec. and the third at 94 in./sec.

As an adjunct to the instrumentation, underwater motion pictures are made at the instant of water impact, and during water penetration, with a camera operating at a speed of 1,000 frames per sec.

The test program for the radiometric sextant radome consisted of 10 test drops, with drop heights varying from two to 42 ft. The desired impact velocity equivalent to sea state five was obtained at the 42-ft height.

The following advantages of the quarry-pendulum method over the conventional free-fall drop test are listed by Allied Research: a) direct wire instrumentation permits positive recording; b) it is known instantly if usable data have been obtained; c) there is precise regulation of the height of drop; d) the impact velocity of the item tested is, for all practical purposes, retained during water penetration; e) the impact angle of the device tested can be accurately established and regulated; and f) no post test recovery problems arise.★

The boom is now falling freely. The triangular break edge will arrest motion after impact of the radome.



"CORE CONCEPT"—NEW APPROACH TO SYSTEMS MANAGEMENT AT S-C

A basic problem in Systems Management has grown out of the one-shot nature of each project. In many cases, after the system is delivered, the team dissolves. Then, when a new Systems project is initiated, the process of assembling a Systems team starts all over. This consumes time, effort and money.

We've done something about this at Stromberg-Carlson. We've created a new approach to Systems Management.

We call it the Core Concept.

We've built a *permanent* managerial staff. Because it is permanent, we've been able to bring in top talent in engineering, supervision, research, accounting—men with the ability and experience to handle major projects simultaneously or successively.

POINTS OF DEPARTURE

in SYSTEMS MANAGEMENT

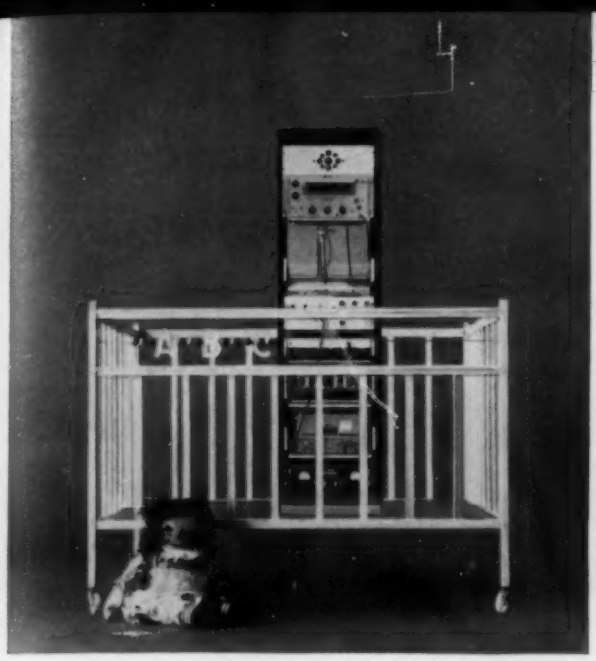
And we've also assembled a group of prime capability sub-contractor companies—*in advance of systems proposals.* As a result, we are able to get projects off the ground faster, to carry them to successful completion with a minimum of lost time or effort—*at a lower cost to Government.*

Right now, in fact, Core Concept is speeding the development of the On-Site Titan Command System and of a new, highly classified ground passive reconnaissance system, to name two of Stromberg-Carlson's Systems Management assignments.

As a leader in electronics and communications, we're qualified to take over additional systems management responsibilities in undersea or CBR warfare, command control systems, and related areas.

Why not let our Systems Management people show you how Stromberg-Carlson's "Core Concept" can be put to work on your program?

STROMBERG-CARLSON
A DIVISION OF **GENERAL DYNAMICS**
1400 N. GOODMAN STREET/ROCHESTER 3, N. Y.



THIS BREADBOARD IS LEARNING TO TALK... AND LEARNING FAST

No, it's not an exotic loudspeaker or other transducer we're aiming for in research at Stromberg-Carlson. It's an electronic device that can turn a coded signal into actual speech. Why?

Well, by encoding your voice for transmission along a channel many magnitudes narrower than that occupied by the original speech sound wave... and by synthesizing this signal back into speech at the other end... we can cram many messages into a given circuit capability, frequency range or bandwidth.

This program demands probing beneath classical phonetics into the very psychological and physiological mechanisms of human communication. It requires mathematical analysis of speech patterns, and it calls for new computer logic.

in COMMUNICATIONS RESEARCH

Already, this research program is well advanced. This year we should complete analysis equipment and partial analysis of speech signals.

A machine that speaks is only one of Stromberg-Carlson's current objectives in research. A random sampling might spotlight such projects as these: Studying and evaluating solid-state materials and devices to meet the requirements of specific radio frequencies. Adding to our basic knowledge of data transmission in order to increase speed and reliability, at lower costs. Enhancing our knowledge of thin magnetic or dielectric films and their application to high-speed access storage systems. Tailoring solid-state molecules into super-sophisticated circuits or circuits not previously possible. In short—we're interested in anything that will lead to a better understanding of electronics and communications—terrestrial, maritime, or celestial.

HOW TO ELIMINATE 99 OF EVERY 100 MINUTES IN SYSTEMS TESTING

SCATE—Stromberg-Carlson Automatic Test Equipment—is just what the weapons system engineer ordered. It is very likely the most advanced, and fastest test equipment available today.

Programmed with punched Mylar tape, SCATE tests an unprecedented number of parameters, makes marginal and contour tests, isolates specific faults, detects performance degradation, predicts probable sources of failure, continuously checks itself, displays a rapid HI-GO-LO and numerical evaluation for each test and prints a permanent record... all in record-breaking time.

SCATE pays off in flexibility and economy, too. Standard building-blocks—solid-state modules using proven, reliable circuits—form the nucleus of the

in ELECTRONIC EQUIPMENT

basic SCATE system. Unique blocks—special stimulus generators and response normalizers—custom-tailor SCATE to the particular test requirements of any missile, aircraft or ground electronic system. And that old bugbear of test equipment—development changes in weapons systems—is no problem at all. Substitution of certain modules keeps SCATE up-to-the-minute, matching any weapons system from prototype to operational status.

Speed? 7000 bits per second. Recently, in a classified area, SCATE reduced a 12-hour manual testing program to less than 5 minutes. This represents a time reduction of over 99%.

In sum, SCATE is the only automatic test equipment that delivers these four critical advantages: (1) fault isolation, (2) self-testing, (3) complete solid-state modularization and (4) in-development flexibility. Descriptive literature on request.

Circle Reply Card No. 12

nanwep: weather by the numbers

Given: 1) 525,000 cubic miles of gas surrounding the Northern Hemisphere; 2) the present temperature, pressure, moisture content, velocity and direction of gas movement measured at 3,000 points in the hemisphere; and 3) the values of these variables yesterday.

Find: The temperature, pressure, velocity and direction of gas movement 24 hours from now.

Method: There are two: 1) apply the knowledge gained by years of meteorological study and experience, apply educated guesswork, and produce what you think will be the condition of the gas in 24 hours; or 2) apply complex mathematical equations to the conditions reported from each measuring station, make 300 million computations, modify the results with the results from adjacent stations, and produce what you know is the best possible prediction of conditions 24 hours from now with existing mathematics and available data.

The first method is prophecy. The second is Numerical Weather Prediction.

The first method has been in use for over a century. It works — most of the time — but it requires hours of work and is subject to much human interpretation. Numerical Weather Prediction can be done in minutes, is subject to a minimum of human intervention, and can produce forecasts of other related phenomena.

The problems which confronted the people who made the first attempts at Numerical Weather Prediction were staggering. The equations are well tried, but it was found that they had to be extensively modified to fit the application. Some method had to be found to extrapolate data for atmospheric conditions where there were no observers, or where the observers' reliability was inadequate.

Early Efforts — In 1922, an English mathematician named L. F. Richardson first conceived the idea of Numerical Weather Prediction. He had data from weather stations from which to make forecasts. He developed the math to find the answers. When he found that it took three months with the aid of a desk calendar to produce the first 24-hour forecast, he came up with the idea of a human computer — 60,000 people — who would perform the necessary calculations. For good reason the dream was never culminated. Richardson had based his try on six non-linear partial differential equations, known to meteorologists as the Primitive Equations. As Richardson learned, these equations cannot be applied to practical problems in their "primitive" form, but in 1939, G. C. Rossby in a classical simplification reduced the equations to a single term.

Then in 1950, a group of mathematicians and meteorologists working at the Institute for Advanced Study at Princeton (sponsored to a great extent by the Office of Naval Research) completed the last step which made Numerical Weather Prediction a reality. With the help of the MANIAC computer, they evolved the mathematics which made it possible to apply Rossby's equation to the atmosphere. In 1954, three agencies joined forces to use the products of the Princeton research. This combination of the United States Weather Bureau, the Naval Weather Service, and the Air Weather Service jointly sponsored the new group — JNWPU (Joint Numerical Weather Prediction Unit).

Equipped with an IBM 701 digital computer, with some of the finest meteorologists and mathematicians, and with blank weather charts, the group set to work to develop the equations and processes which would produce better forecasts than did the Weather Bureau meteorologists.

From the Navy's viewpoint, JNWPU was not the whole answer to weather problems. JNWPU's forecasts were made at 18,000 ft — great for airline pilots, but not for submarine skippers. Then there was the problem of JNWPU's limited resources, which could not support a full-fledged Navy numerical weather program.

NANWEP Organized — The solution was NANWEP, the Navy Numerical Weather Problems Group, established first in the Census Bureau in Washington but later moved to Monterey, Calif. It had two men in 1959; now it is a busy research

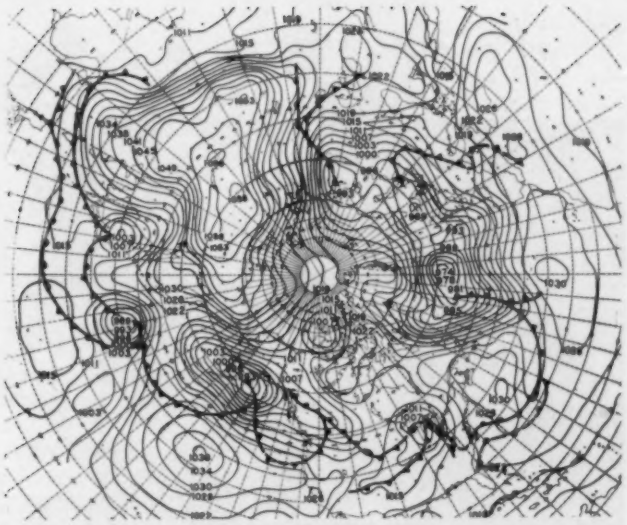
and operational weather center with 30 people. Next February NANWEP will be established as a separate activity with the job of providing meteorological and oceanographic forecasts to the fleet and other Naval activities.

The basis of numerical weather forecasting is surprisingly simple. Weather is caused by air movement and variations in atmospheric pressure over a given area. If you know what these variables were yesterday and what they are today, the application of certain equations will tell you what they will be tomorrow. Precipitation and temperatures are the result of pressure conditions. If the computer can produce tomorrow's pressure conditions, then it is possible for a meteorologist to deduce the temperature and precipitation which will result.

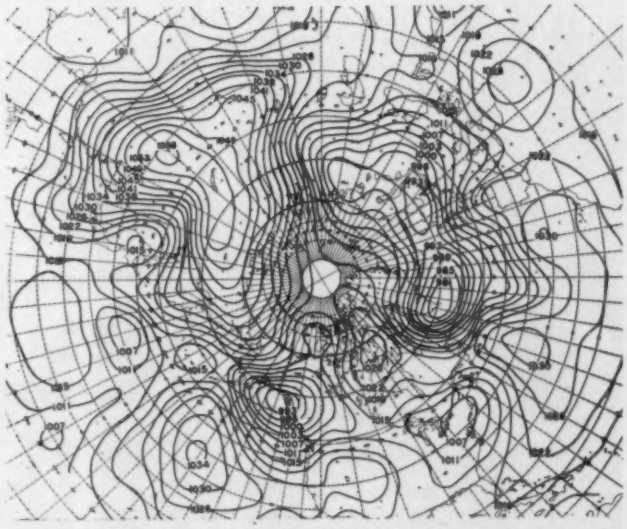
NANWEP uses a small, quiet, Control Data Corp. 1604 Digital Computer equipped with four Ampex Model FR-300 Digital Tape Transports. Weather reports reach NANWEP on six 100-word-per-min. teletype circuits. There are 10,000 weather observation stations which could report, but delays in communications (and sometimes weather) produce an average of 3,000.

How It Works — Input to the computer is through punched tape prepared from the teletype reports. Soon a CDC 160 Satellite Computer will be added to the system. Then it will be possible for the computer to read the six teletype circuits simultaneously, store the data in magnetic-core memory, and through an Ampex transport, transfer the data to magnetic tape. But this is not enough. Teletype information must be edited — redundant or impossible reports thrown out — and converted into a consistent measurement language (knots, centigrade, millibars, and so on). All of this will be done by the Automatic Data Processing Unit with the help of the CDC 160 — and best of all — without requiring any human assistance.

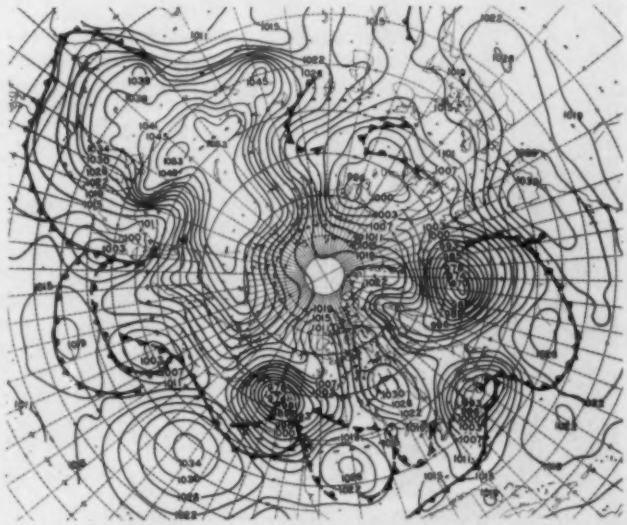
Once the data has been processed, the second step is to make a weather map of existing weather. A grid of lines spaced 205 nautical miles apart is placed over the Northern Hemisphere. Each grid intersect is assigned an address and the weather reports from stations surrounding each intersect are used to interpolate a pressure value for the intersect. If there is not enough data from the area in the immediate vicinity of the intersect, then the computer scans out from the point in ever-increasing circles until enough data is found from which to



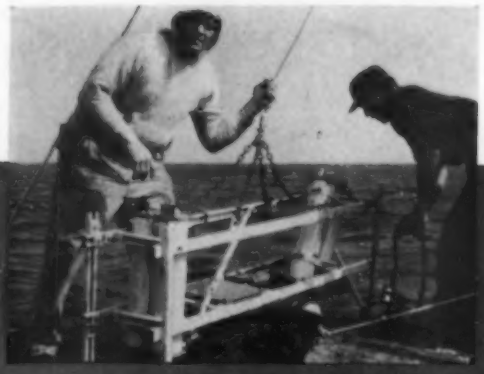
Produced in 1957 by JNWPU (see story), these maps are representative of NANWEP's current output. The above map shows existing weather . . . .



. . . as reported by weather stations. The center map is the computed forecast for weather . . .



. . . 24 hours later. The bottom map shows what the weather actually was 24 hours later.



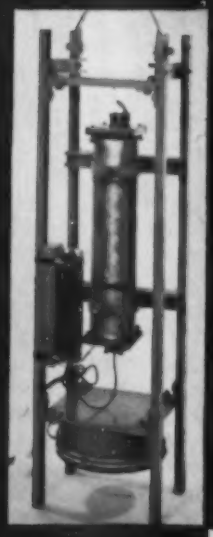
PROVEN IN OCEAN DEPTHS MORE THAN 5 MILES DOWN

▼ **Automatic Underwater Photography Systems.** This automatic oceanographic photography system has been used at depths to 27,000 ft. and is test-proven for use at the ultimate ocean depths.

Powered by self-contained batteries, the unit needs no electrical cables to the surface.

A camera-mounted sonar pinger is used to position the camera at the proper distance above the ocean floor. Once the camera unit has been positioned, photography is automatic and two cameras make stereo pairs of photographs on 35 mm. film every 12 seconds for 100 minutes using an integrated electronic flash for illumination. Depth, pressure, time, location, date and ship identification data are automatically logged with each exposure. Two models are available: CA-9 for use in depths to 37,500 ft. and CA-8 for depths to 6,500 ft. For complete specifications, write for Data Sheet #2000

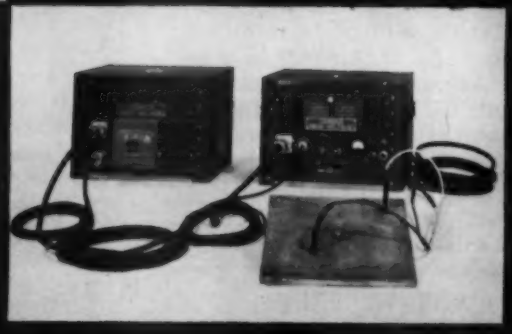
▼ **Sonar Pinger.** This battery-powered device is finding ever increasing applications in oceanography.



The unit will run for over 16 hours on one charge giving out one 12 kc ping per second at an accurately timed rate. This precise timing allows a recorder on the ship above to be synchronized to the pings. By comparing the time of arrival of the direct pings with that of the bottom reflected pings the distance from the pinger to the ocean bottom is shown.

Sonar Pingers are used in positioning oceanographic instruments such as underwater cameras, coring tools, water sampling bottles, etc. . . . and in making detailed bathymetric surveys of the ocean floor. Write for Data Sheet #3000.

▼ **Sonar Thumper — A new, high intensity underwater sound source.** This electronic device was developed primarily for making marine seismic surveys. It emits a high intensity "thump" underwater at a rate of up to 2 per second. The echoes of the "thump" show not only the water depth, but the geological structure of the bottom. This information is invaluable to those making underwater constructions, such as missile launching platforms, transducer arrays, breakwaters, tunnels and bridges. The unit delivers a clean, highly consistent pressure waveform.



Additional applications include underwater sound transmission studies, missile impact simulation and navigational applications. Complete specifications on request.

E&G

Edgerton, Germeshausen & Grier, Inc.

160 Brookline Avenue, Boston 15, Massachusetts

Circle Reply Card No. 15

make the interpolation, or until the circle gets so large that interpolation would be inaccurate. When all of the data has been analyzed, the computer could produce a pressure-pattern chart for the existing weather in the Northern Hemisphere.

At this point it does not make an actual weather forecast, but predicts pressure changes at each grid intersect as a function of time. The application of mathematics like the Rossby equation produces the values which will exist in one hour. These values are used by the computer to predict what will happen at the end of two hours — and so on — until the desired forecast has been reached, usually 24 or 48 hours. This is the map produced by the high-speed printer. In making the forecast, the computer will have performed about 300 million computations. The finished map is in the form of pressure patterns.

An area of constant pressure is shaded with the same numeral, say 7, and the pressure for that area is printed at the grid intersects which define the area. To the eye, the completed chart will appear as a sea of digits but with subtle differences in grey shade. A meteorologist places an acetate overlay on the pressure chart and traces the lines which define the areas of constant pressure. This chart can be transmitted to the fleet and short stations by facsimile and can be interpreted by any competent meteorologist. Stations which cannot wait for the facsimile transmission can receive the pressure chart by 1,000-word-per-min. teletype and draw their own maps. When all the automatic data processing equipment is installed, the complete forecast, from incoming teletype data to outgoing teletype data, will take just 40 mins.

Ship-Routing Application — Some of the forecasting products and by-products planned for production in the next year include sea-height analysis and prediction, precipitation forecasts, and hour-by-hour weather forecasts for 10 naval stations on an experimental basis. Another interesting application will be to the problem of optimum ship routing.

Because the NANWEP computer can predict what the surface pressure-pattern is going to be in any ocean in the Northern Hemisphere, it can predict the wind direction and velocities which will exist. Since wave height is a function of these two variables, the computer can predict the wave action for a three-day period.

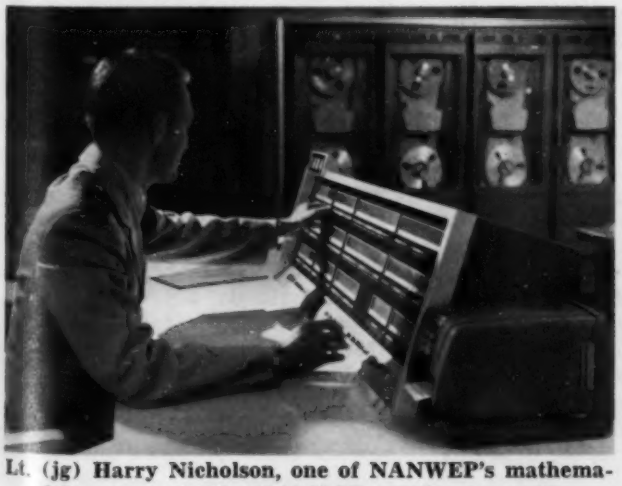
Assume that a ship is navigating from Yokosuka, Japan, to San Francisco. The computer would be told how that particular ship will perform in different sea conditions, and would figure out the wave forecast in the Pacific for the five-day period. It would then pick five initial courses from Yokosuka, perhaps 10 degrees apart, and with the information on the ship's performance, could predict how far the ship would travel in one day on each course. The "one day points" would be connected by a curve. New courses would be drawn for the second day, perpendicular to the first-day curve, at points 200 miles apart. This would be continued until a three-day plot had been established. Starting at the end of the longest third-day course, a line could be drawn through the plot following the best courses for each day. The result is the optimum course for that ship for those three days. The ship's navigator could request three courses — optimized for least time, least time with a limit on the height of waves encountered, or least time with smooth seas.

NANWEP Personnel — In charge of NANWEP is Cdr. Paul M. Wolff, 39-year-old meteorologist. Cdr. Wolff graduated from Wittenberg College with an AB in Physics in 1942, then received a commission in the Navy. He was sent to the University of Chicago for a course in meteorology, then served aboard several carriers in World War II.

In 1950 he completed his Masters Degree in Science at the Navy Post Graduate School at Monterey. He was assigned to Research Project AROWA, on the East Coast, and from there went to JNWPU, the parent organization of NANWEP. In 1958 he was named OIC of NANWEP.

The NANWEP organization consists of two sections, Operations and Research. Twelve civilian employees and officers do the research under Mr. G. Arnason. Also on the research staff is Mr. L. P. Carstensen, who, along with Arnason, has done much of the basic research in this young science. NANWEP's Operations Section is now in its "shake down" phase, but soon starts test transmissions of data and analyses to the Pacific Missile Range. Total manpower of NANWEP will eventually reach 40.

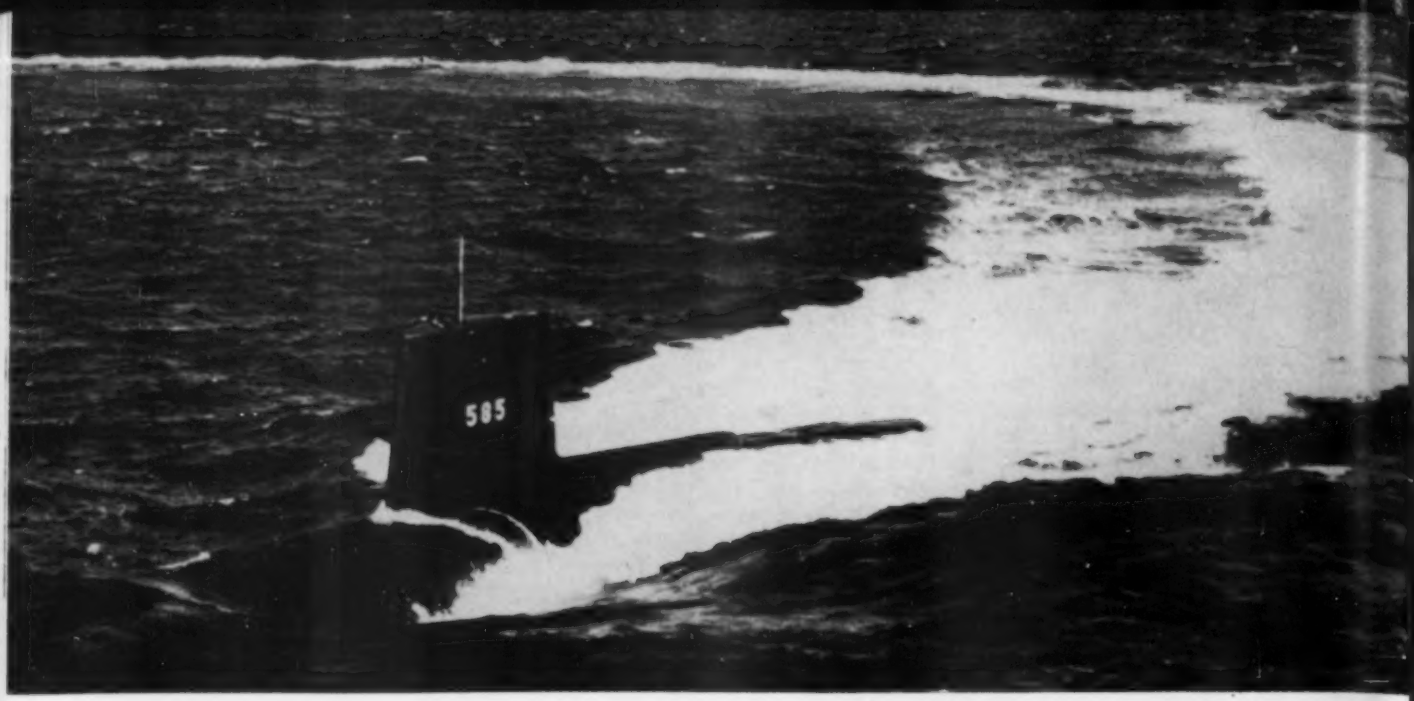
Cdr. Wolff and the other NANWEP scientists feel that it will be a long time before we obtain enough measurements of existing weather to make absolute predictions of any future weather. The best we can do now is to refine the equations and programs which Numerical Weather Prediction now uses until we have exhausted the potential of the available data. This, combined with a careful analysis of what went wrong with bad predictions, will produce better forecasts than are possible today. Yet there will still be the element of chance, and ten years from now the papers may still print ". . . with a possibility of rain in the afternoon."★



Lt. (jg) Harry Nicholson, one of NANWEP's mathematicians, operates the NANWEP weather computer.

Navy Airman Daniel Napier puts a fresh reel of tape on one of the on-line magnetic tape units.

(This article is condensed from READOUT, a magazine of Ampex Data Products Co. Copyright 1960, Ampex Corp.)



toxicology studies

key to undersea survival

UE Staff Report

The POLARIS Fleet Ballistic Missile, now operational with the U.S. Fleet, is excellent testimony to the combined ability of American Military services, hundreds of industrial companies, and special research outfits. These organizations worked together over long periods on a crash basis, to produce a weapon system of tremendous strength and flexibility . . . and on schedule.

An unpublicized phase of this huge program — a small but essential facet in the entire effort — is the contribution of men whose responsibility it was to guarantee that the missile launching pad, the nuclear submarine, would be safe to live in for months underwater. This is the story of a small group of men assigned to a large project — the U.S. Navy Toxicology Unit.

The story begins early in 1957, when Vice Admiral W. F. Raborn, Director of Special Projects for the Bureau of Naval Weapons, was charged with the development of Navy's most powerful weapon, an intermediate range missile that would be launched underwater from nuclear - powered submarines to strike at cities hundreds of miles inland.

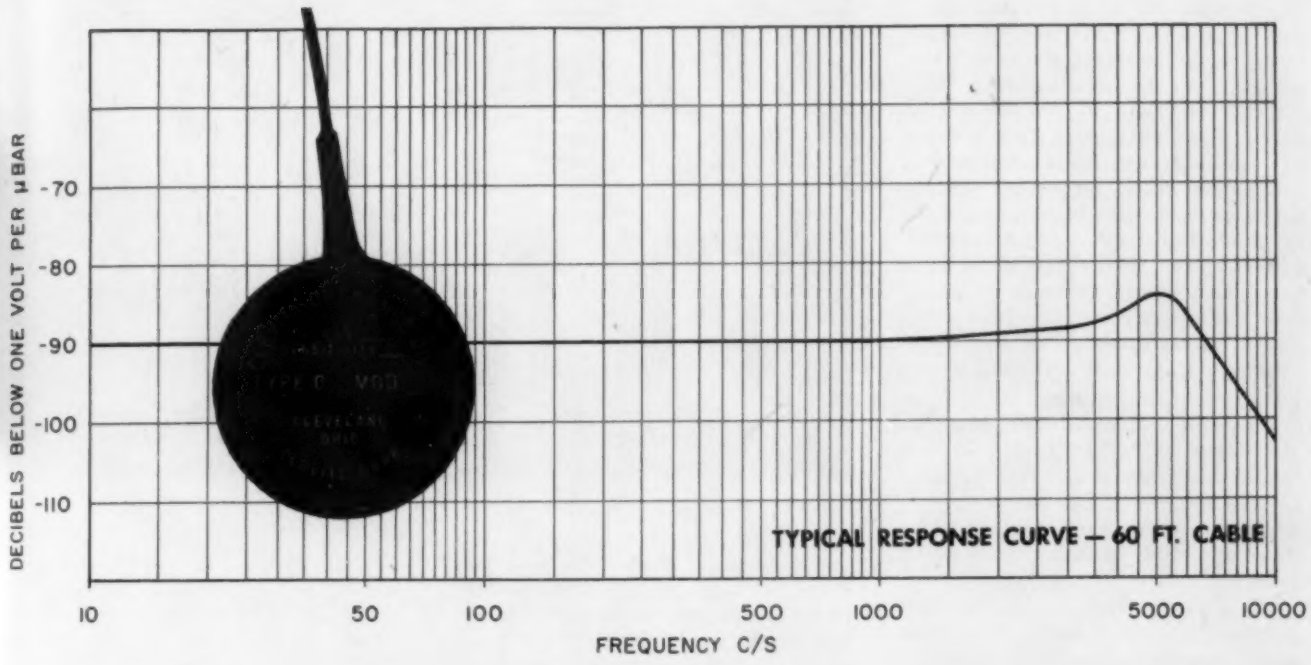
Background of Program — Atomic submarines were expected to operate on war patrol for four months or longer, without surfacing or even rising to periscope depth. There were many obvious unanswered questions in the areas of psychological and physiological reactions of individuals to such a closed environment. One of the least explored areas was that of the Toxicological substances that would be indigenous to the submarine, that would be created by man himself, or that would be introduced into the environment after extended periods of operation.

Because of the crew's continuous confinement and exposure to the same atmosphere, around the clock for months, the amount and effect of contaminants in the air would be a vital health factor. The current body of toxicity information available was inadequate. Some data had been developed for industrial applications, but these studies had been based on the eight-hour day, 40-hour week. Under the radically different conditions in the A-subs, new factors would be introduced and new levels of toxicity would have to be analyzed.

Adm. Raborn asked Rear Admiral Bartholomew Hogan, Surgeon General of the Navy, to give full medical support to ensure that the POLARIS missions would not be retarded because of health problems. Adm. Hogan immediately set up a crash habitability program to determine, isolate, and evaluate the factors that might affect the lives of the men who would man the nuclear subs.

Adm. Hogan gave to Rear Admiral E. P. Kreuz, Commanding Officer of the National Naval Medical Center, in Bethesda, Md., the responsibility for setting up a means of establishing health standards that would not only prevent serious medical diseases, but would prevent any degradation in performance. "To provide rapid practical answers to toxicity problems . . . not to engage in basic research," the Navy Toxicology Unit (NTU) was set up with

CLEVITE OYSTER



Unusual uniformity of response is provided by the Clevite Oyster*, newest underwater transducer in the Clevite line.

This characteristic eliminates the need for sorting units into performance groups, and simplifies circuit considerations in devices incorporating them. It also makes the Oyster an excellent module for array design in the medium and low frequency ranges.

The Oyster, now available for general-purpose applications, combines classically simple transducer design with PZT-5**, the most advanced piezoelectric ceramic. Results are low cost; unusual strength and tolerance of rough handling; high performance; and compactness. Diameter of the device is 2 in. Thickness is ½ in.

The Oyster is substantially nondirectional over its normal frequency range. Response characteristics are independent of temperature and pressure over the ranges of normal usage.

The standard Type O Oyster is tested to 150 psi, more than three times the current requirement, and is adaptable for any reasonable operating pressure. Basic design can be modified to provide various sensitivities, and for use as a medium power transmitter.

*Trade Mark

**PZT*-5; A Clevite Lead Zirconate Titanate Ceramic

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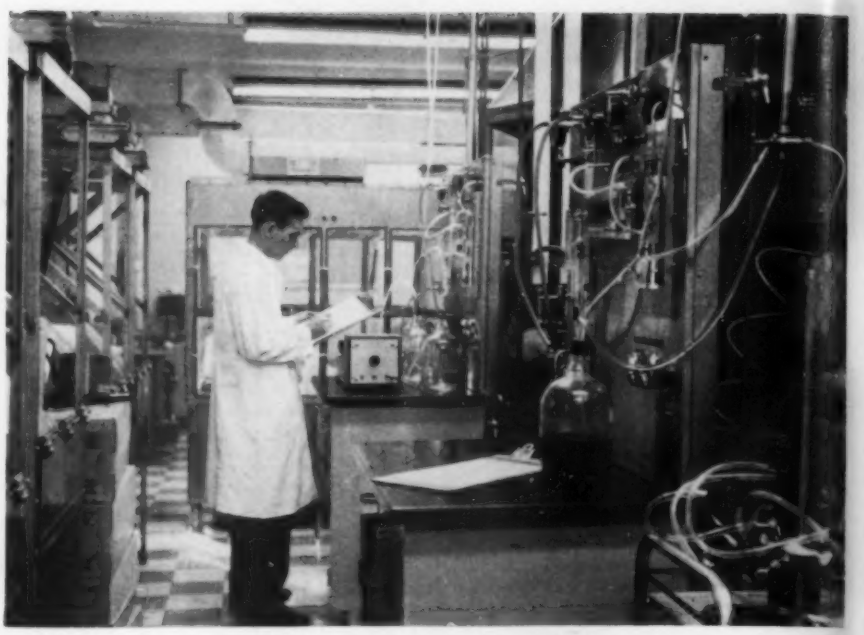
Commander Jacob Siegel, a biochemist, as Officer in Charge. "Rapid" and "practical" were to be the key words in Cdr. Siegel's operation.

Cdr. Siegel and his staff were faced with the problem of determining those elements that might prove toxic, isolating them, and devising a means of measuring their effects on man, all on an urgent basis. The Toxicology Unit decided to conduct extended continuous inhalation tests, exposing several kinds of animals to varying amounts of the suspected contaminants for periods from 30 to 170 days at a time. Test chambers were to simulate the submarine environment as closely as possible.

WTA's Role — Washington Technological Associates, Inc. (WTA), an engineering research and development firm in Rockville, Md., just a few miles from the Naval Medical Center and NTU, was asked to furnish the necessary equipment for thorough and detailed toxicology studies.

WTA had previously worked closely with the Navy in many research and development programs—ranging from massive systems for handling missiles aboard ship to complex miniaturized go-no-go indicators for the POLARIS launch test vehicle. WTA experience in system analysis and design was quickly applied to the problems at hand.

WTA engineers designed and built six chambers, each constructed to rigid specifications. WTA was also responsible for system performance and reliability. The chambers



An NTU technician monitors control panels of toxicology chambers.

are six-sided, made of steel and Plexiglas. Conical tops and bottoms create a cyclonic distribution of air and contaminants, and ensure a homogeneous contaminant pattern.

Each chamber can handle, in two layers of cages with varying individual cage components, about 60 rats or hamsters, 12 monkeys or rabbits, four dogs, or six chickens. Because the contaminants affect animals differently, a new material is usually tried on several kinds of test animals. Based on the assumption that man's reaction will be as acute as that of the most responsive test animal, the animal that proves most sensitive to the contaminant is selected for subsequent tests.

The group of test chambers is arranged so that one chamber can be used as a control and five for tests, or pairs of two chambers can be used, one for test and one for control.

Contaminants in the form of dust, mist, gas, or vapor are added to the intake air and circulated through the chamber. The intake air can be regulated to limits of 60 to 110 degrees F. and 45 to 90 per cent relative humidity. Rate of feed and particle size of the toxic material are finely regulated, and air samples can be taken at fixed points in the chamber. Flow rates and pressure can be read from the control panel. After the contaminated air leaves the chamber, it is filtered and processed to remove all toxicity and only the air is released outside the building.

A unique feature of the chamber is that they are operated continuously, day and night, for periods up to 30, 90 or 170 days. The chambers are open only 15 to 20 minutes a day — long enough for laboratory technicians to feed the animals and clean the cages.

NTU's Target — The aim of the NTU study is to form a dosage response curve, starting with maximum toxicity, and decreasing the toxic effect until a no-effect dose is achieved. The results of the study are translated into terms of humans and the parameters of human absorption established. The submarine then operates at a level safely below this parameter.

So far more than 200 materials have been identified aboard ship as

Rear Admiral E. P. Kreuz congratulates Commander Jacob Siegel and his staff of the Navy Toxicology Unit on their success.

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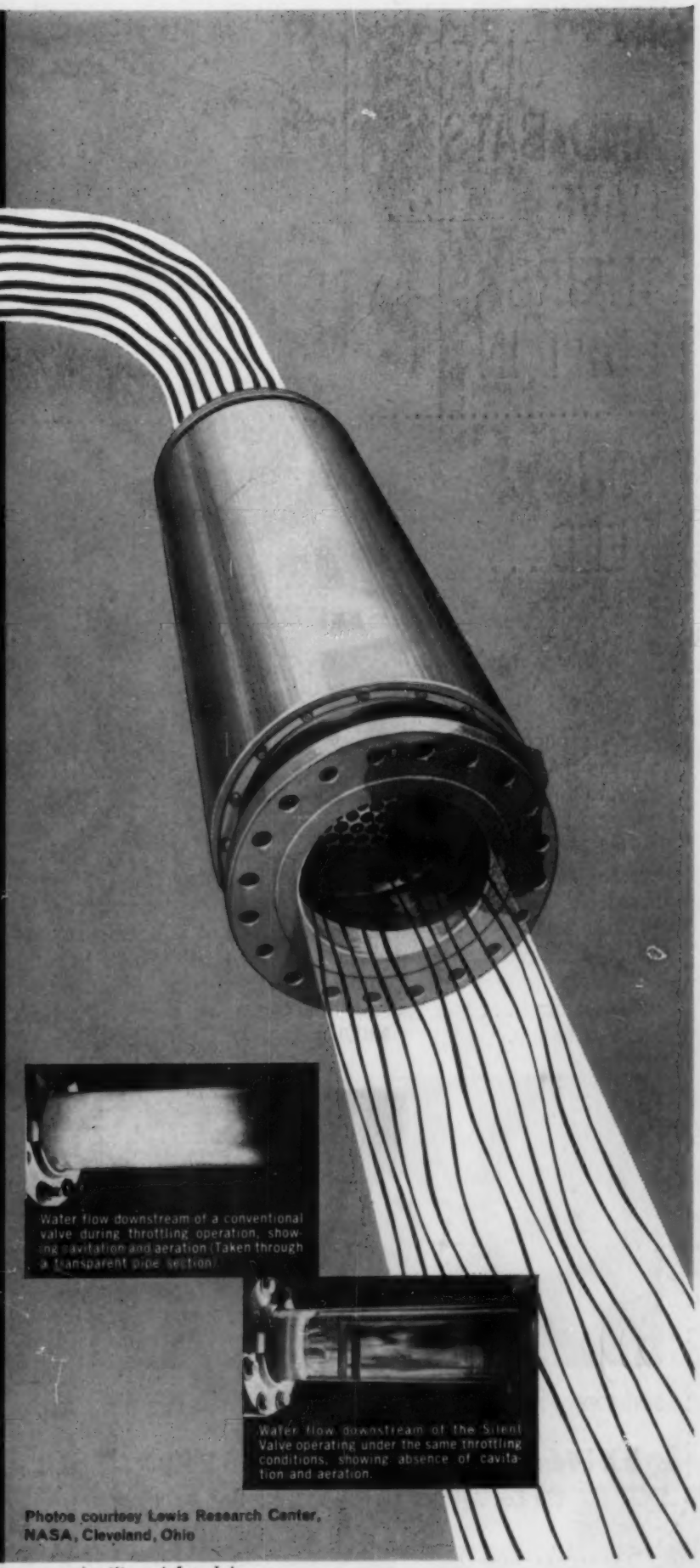

Water flow downstream of a conventional valve during throttling operation, showing cavitation and aeration (Taken through a transparent pipe section)

Water flow downstream of the Silent Valve operating under the same throttling conditions, showing absence of cavitation and aeration.

Photos courtesy Lewis Research Center, NASA, Cleveland, Ohio

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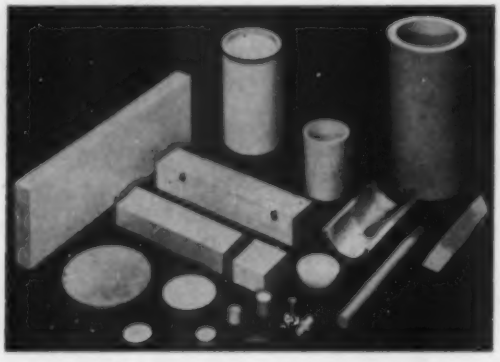

✱ *MICHELITE (as well as standard barium titanate) transducer ceramics can be supplied in tubes to 6" diameter... bars to 1"x4"x12"...discs to 6" diameter x 1" thick. The sonar source shown at top, made of special matching segments, is 8 ft. in diameter. Special cross sections are available on order.*

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known or possibly toxic substances that present potential health hazards. Many of these materials are new and their properties are not thoroughly known. Others are well-known substances with new applications. Some are exotic in nature, like high-energy fuels, while others are run-of-the-mill compounds like carbon tetrachloride and freon. Some are seemingly innocent materials such as paint thinner. Among the most difficult are triaryl phosphate compounds. The common denominator is their established or potential toxicity to the human system.

More than 100 of the materials so far identified are tied in with the FBM submarine. These have been screened and the materials of immediate interest — those key compounds that seem to have the most serious toxicological implications —

Lab-bred test animals make no attempt to escape as an NTU technician changes their water.

have been selected for animal tests.

NTU has also made extensive studies aboard ships and submarines to analyze such elements as concentration of mist at the compressors of submarines using triaryl phosphate fluid.

The staff of NTU, a small group of purposeful men aided by the resources of WTA's engineering research laboratory, have made important contributions not only to the POLARIS program, but to the success of the globe-circling TRITON. Looking to the future, some of the results of the Navy Toxicology studies, in detecting and measuring minute quantities of material and establishing the biological parameters in a sealed environmental system, may be used in other fields of research, such as investigation of the toxicity parameters for fallout shelters or the closed ecology of space vehicles.★

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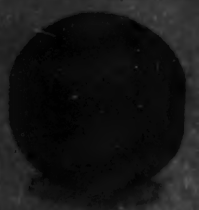
Qualification test chamber designed to standard U.S. Navy specification. 18 in. diam., .041 wall thickness. 7.78 lbs. total weight including fittings and liner; 4.72 lbs. net weight of fiberglass-plastic. Tested to 650 psi burst, with hoop stress of 146,473 psi at burst. Actual strength-to-weight ratio of 2,035,000 in.

80 cu. in. bottle for storage of concentrated sulphuric acid. 5 in. dia., weight 5 lbs. including Teflon liner wound into structure. 150 psi operating pressure, 300 psi proof, 750 psi min. burst. Minimum life of 1000 operating cycles from 0 to 150 psi. Leakage guaranteed less than MIL-R-8573A.



Spherical bottle for nitrogen storage in space satellite. 480 cu. in., 10 in. dia., 10 lbs. total weight. 3000 psi operating pressure, 5000 psi proof, 6667 psi min. burst after proof plus 25 operating cycles. Leakage guaranteed less than requirements of MIL-R-8573A.

2700 cu. in. bottle for nitrogen storage in space satellite. 2 ft. long, 17 in. dia., weight 31 lbs. including fittings. 3000 psi operating pressure, 3750 psi proof, 6000 psi min. burst after life of at least 400 operating cycles from 0 to 3000 psi. Leakage guaranteed less than MIL-R-8573A.

This is Hystran, Lamtex's new space-age material that is solving high pressure storage vessel problems considered impossible or impractical with previously available materials such as aluminum, steel or titanium! A fiberglass reinforced plastic material, Hystran is filament-wound on automatic machines developed and built by Lamtex. The unretouched close-up photo shows the smooth finish and precise control of filament angles and spacing, resulting in a perfectly uniform, predetermined distribution of fiberglass and plastic, particularly when winding the calculated end shape. Equal tension control on each fiberglass filament is automatically maintained during winding, insuring almost progressive fiberglass failure under high stresses.

In addition to the superior strength, weight and physical properties of Hystran, Lamtex's production-proved design and fabrication methods offer considerable savings in engineering time and tooling costs, plus a new degree of flexibility in the choice of sizes and shapes of pressure vessels. Standard procedures and production facilities are now available at Lamtex to handle—on a production basis, not prototype or experimental—filament winding of pressure vessels and other structural shapes up to 7 ft. dia. and 30 ft. long.

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Aluminum	.097	80,000	.83
Titanium	.163	160,000	.98
Highly Heat Treated Steel	.283	240,000	.85
HYSTRAN	.072	165,000*	2.29

*Biaxially stressed hoop tension

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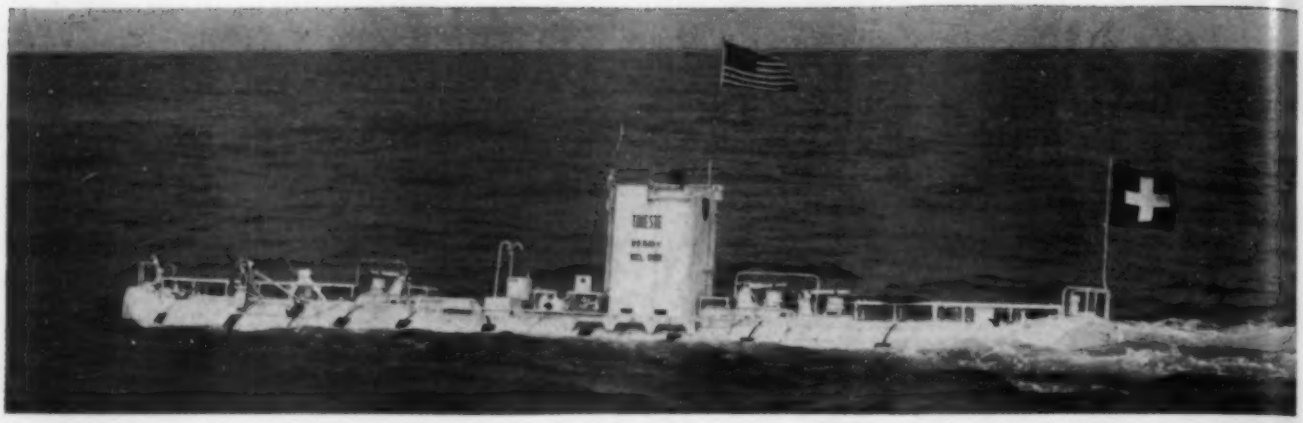


oceanography

let us make it useful

By Capt. Thomas D. McGrath, USN

Recent ASW literature has stressed the importance of oceanography in anti-submarine warfare. Writers in this field warn us of the need for more oceanographic research and more oceanographers, and point to the concentrated effort being made by the Soviet Union. The Navy has increased its emphasis on gaining knowledge of this "inner space," and Navy's Hydrographic Office is making good progress in predicting oceanographic conditions.

But collecting data and gaining knowledge of this "inner space," are not enough. To be of real value, the data must be translated into operating instructions and practical rules for the man at sea. The data must be made applicable to the equipment in use so that the fleet can take maximum advantage of water conditions — at the time of measurement, at the scene of action, and at the time of encounter.

Present techniques and knowledge are not being utilized fully, and it is necessary to bring applications up to date and insure that future gains in oceanographic knowledge can be quickly translated into forms usable by the operator.

Since sound is our basic detection medium, fully exploiting the application of present knowledge of sound behavior in sea water for operational use is a first requirement. This knowledge is needed in all ASW elements: surface, subsurface, air, mine fields, and fixed installations.

The operational exploitation of oceanographic knowledge has lagged in the past because the operator had little leeway for control. Against straight running contact torpedoes, surface ships with transducers fixed to hulls could do little but accept the limitations of the medium. Aircraft detecting elements were fixed in depth, affording little flexibility. Submarines were primarily conceived as offensive weapons against surface targets, and their main concern was in avoiding detection. Mines were limited to shallow water, and targets had to be within a few yards. But with variable-depth transducers, deep hydrophones, anti-submarine submarines, deep-running homing torpedoes, anti-submarine mines, and high-power, low-frequency sonars, the latitude for exploiting differing sound paths and other oceanographic parameters is increasing and exploitation of these tools is imperative.

Captain Thomas D. McGrath is Commander of U.S. Navy's Key West Test and Evaluation Detachment at Key West, Florida.

The operating forces have had prediction tables for sonar performance. These were predicted on statistical analysis of overall conditions and were applicable to hull-mounted sonars only, with usefulness limited to varying the routing of anti-submarine groups and determining the spacing of ships in screens. Even this application has been marginal because the spacing is most often fixed by number of ships available. The shipboard operator has considered sonar conditions like the weather — something he could do nothing about — and has classified them as good or bad. To the operator they have been an ally of the opponent, merely making his job more difficult. Now, means must be provided to permit turning these environmental conditions to advantage, not only for surface ships, but for submarines, aircraft, helicopters, and for all varieties of new equipment becoming available.

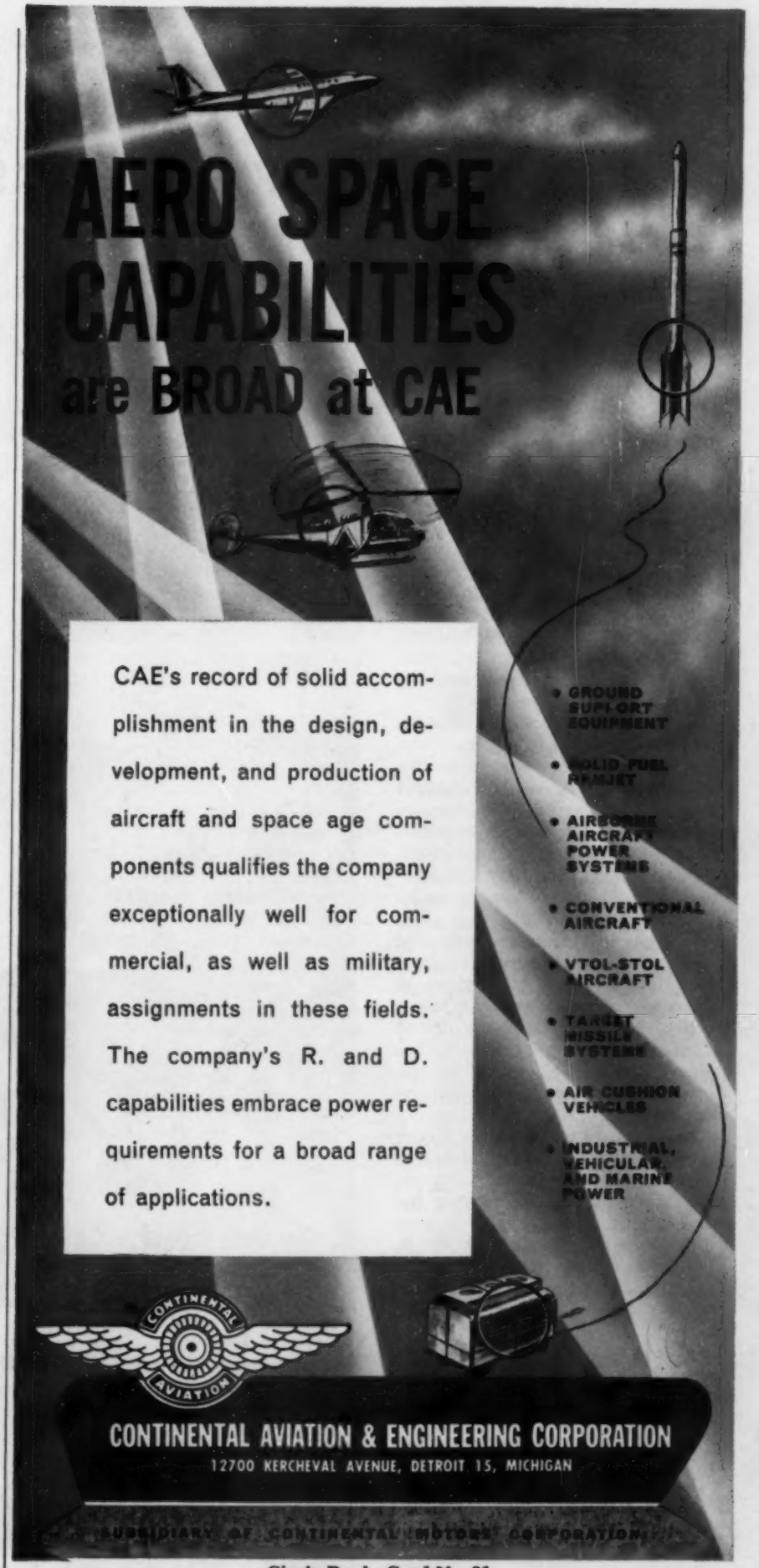
The statistical approach is probably wrong because the opponent has the same sources of information and will use them to his advantage. Therefore, he is likely to be encountered not under average conditions, but under the conditions most advantageous to himself. In addition, any anti-submarine unit can expect only a few encounters in its useful lifetime. Its success or failure at that time determines if the expense of its construction and operation is justified. Therefore, averages are not good enough — maximum effectiveness at time of encounter must be

the aim. The foregoing should be sufficient to convince even the most hard-boiled skeptic that oceanographic research needs to be paralleled by a companion effort to apply the research results to operational conditions and make them readily available to the anti-submarine forces at the point and time of contact.

The known variables affecting the behavior of sound in water are many: temperature distribution, salinity, marine life, depth, bottom contour, bottom type, surface conditions, and others — some undetermined. Many of these produce variations in sound velocity. Most predictions are now based only on measurements of temperature. Sound-velocity measurements would encompass many more of the variables and will probably prove to be the more valuable parameter. For the sonar operator, the most useful information would be knowledge of what happens to his sound energy, the paths it follows, and how far it is likely to go. Ray-path diagrams give this information but are essentially analysis tools. Rapid presentation of this information, however, would permit range prediction, allow range correction for varying paths, give an indication of target depths, and assist in classification. Production of such diagrams appears easily adaptable to simple computers.

Therefore, it appears that the initial step in gaining operational effectiveness from our oceanographic program is to provide means of measuring sound velocity in water under operational conditions, and further to present the variations as they effect the path of sound in water. This information could determine 1) where the transducer, sound source or hydrophone should be placed; 2) where the anti-submarine submarine should be and its attitude for best detection; 3) whether reflection from the surface or bottom is present and its effect on range; and 4) the most probable range bands for detection and tactical application of the foregoing.

Industry is certain to be involved in providing the instruments for and analyzing elements of our expanding oceanographic program. But these will be laboratory instruments, and few in number. The more useful contribution would be in providing the measuring and analyzing equipments which will be required by every anti-submarine unit if the maximum effectiveness is to be obtained from our anti-submarine equipments at sea.★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cathodic protection checks corrosion

By
Commodore A. D. Hunter, CEC USN (Ret.), *Engineering Consultant,*
and
C. H. Horton, *The Hinchman Corp.*

Announcement by the Coast Guard of plans to replace 22 lightships with "Texas" type platforms, mostly along the East Coast, puts this unique structure back in the engineering news, and serves to remind that one of the most serious design problems is corrosion prevention.

Some years ago the Navy Bureau of Yards and Docks was assigned the task of designing and building a number of these "Texas Towers" on the continental shelf as platforms to support aircraft-warning radar installations.

As with all structures built in seawater, corrosion presented the Navy with a serious problem. In this case, the problem was recognized early and necessary steps were taken during the design period. The Bureau retained The Hinchman Corp., of Detroit Mich., to study the situation and to design an adequate system of protection.

The Bureau's engineers prepared a plan to manufacture the steel structures on shore, float them to the proper locations, and then lower them to the ocean floor. A life of at least 20 years was desired. The towers were of a unique design. None had ever been built in the open ocean.

The structure called Texas Tower No. 2 was installed first. Meteorological and oceanographic information was meager. Water-depth at the point of installation was 50 ft with a tide range plus or minus three ft. There was a current of four knots, changing 360 degrees in direction every 24 hours, with 20 ft waves the rule.

At Tower No. 4 the design criteria were different in some respects. Winds of 70 to 125 mph were to be expected, and waves 35 ft breaking and 60 ft non-breaking had to be taken into consideration.

During the construction of Tower No. 2, on August 11, 1955, Hurricane "Connie" hit with waves 67 ft high. Currents as high as 20 knots were measured.

Corrosion Considerations — The corrosion to be expected on vertical steel members in sea water is dependent on the condition of the metal surface itself, protective treatments or coatings, water characteristics, temperature, velocity, marine organisms, and position of the area vertically. All mill scale was to be removed from the surface of the tower caisson, due to its detrimental effect on the life of the steel.

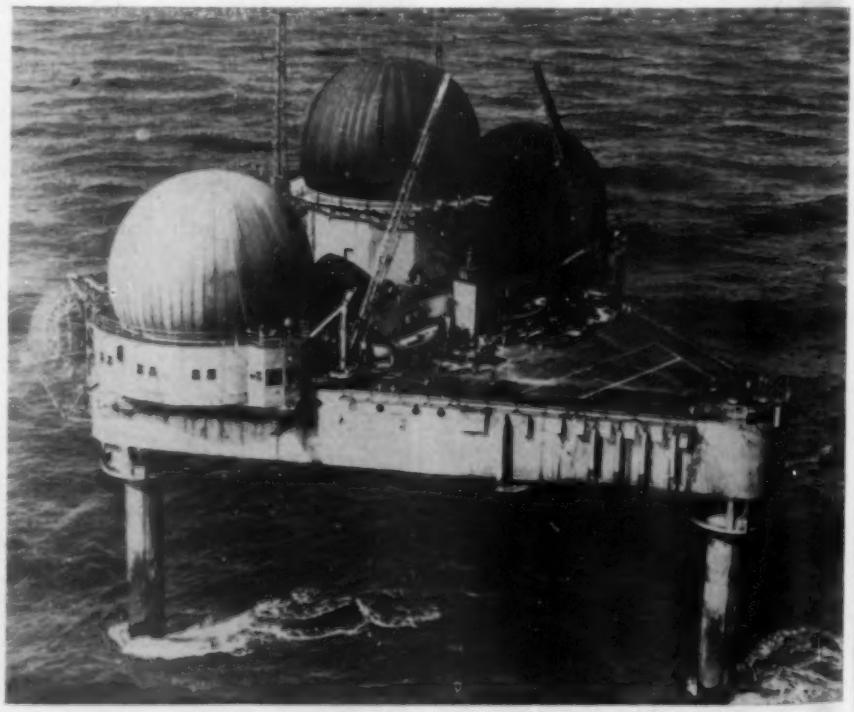
Pure sea water contains approximately 3.5 per cent dissolved salts—primarily sodium chloride, with lesser amounts of calcium and magnesium salts along with many other compounds. The principal corrosive agent is the chloride ion and the principal inhibiting agent is the bicarbonate ion.

The average corrosion rate of steel in sea water throughout the world is approximately five mils per year (0.005 in. per year). Localized corrosion in the form of pitting may be as much as two and one-half times this amount.

Corrosion rates also increase with an increase in water velocity. The corrosion of steel is approximately four times as great at five ft per sec. (FPS) as in stagnant water.

The effect of temperature on increasing the corrosion rate is to a great extent offset by marine organisms, which thrive at higher temperatures and attach themselves to the steel. The lower water temperature of the temperate zone tends to decrease the corrosion rate; however, fewer organisms exist in temperate waters, and thus more area is exposed to corrosion.

Corrosion action was determined to be most severe in the tidal zone. This zone is subject to corrosion while submerged at high tide, and is subject to a greater corrosion rate at low tide from alternate wetting and drying. This zone was to be



Cathodic protection helps lengthen life of the "Texas Towers."

protected from corrosion by Monel sheathing from —13 ft (13 ft below mean water level) to plus 22 ft.

At first the Monel was expected to accelerate corrosion of the steel, due to the dissimilar nature of the two metals. But tests indicated the Monel would, in fact, lower the steel corrosion.

The caisson was to be jetted into the hard sand bottom for approximately 50 ft. Thus 50 ft of the caisson would be in sand and 50 ft in water, with the upper 13 ft of the submerged portion protected by Monel. A bitumastic coating was to be applied to the steel caisson from —13 ft to its lower end. This coating was expected to be partially lost during installation, and completely deteriorated by the end of three years.

How Cathodic Protection Works— The submerged portion of the three tower piles was to be unavailable for any maintenance on the exterior. Since corrosion prevention could not depend on the periodic application of coatings, electrochemical means—specifically, cathodic protection — was investigated. In applying this type of protection, an expandable anode is placed in the water and a direct current flows from it through the water to the submerged steel surface. The steel surface is the cathode in the electrolytic cell—thus the term "cathodic protection."

This means of combating corrosion has been proven the most economical of all for quay walls, piers, ships, drydock caissons, floating drydocks, and other types of marine structures, as well as for pipes, tanks, and cables on the shore. The engineering of the cathodic protection system involved consideration of current requirements, protection criteria, power supply, anode design, and the effect of storms on the system.

The prime consideration was the electric current requirements. Use was made of the reports and data from similar work on shore installations. Amount of current depended on expected corrosion rate, water velocity, polarization of the steel in the water, marine growth, temperature, and possibilities for deposition of alkaline products from the water. A current calculated to be 42 amperes was decided upon for Tower No. 2. This was expected to cause a protective potential of —0.85 volts between the steel caisson and the half-cell in the water.

The economical source of power was determined to be rectified alternating current as opposed to a galvanic type of anode, such as magnesium or zinc. (The material cost of zinc amounted to more than that of steel.)

One of the more important engineering considerations proved to be the hydraulics of the anode. Here is where electrochemistry and hydraulics met head on. The anode would be pushed and pulled in all directions of the compass due to an estimated water current at times of 22 fps. Anodes of various materials were studied. A one-year life was decided upon for the anode, and the weight of the various materials were computed from known electrochemical deterioration rates. This known weight of anode material was assumed to be in several shapes. The

A deteriorated steel anode—original size 18 in.—ready for replacement.

resultant drag force was computed from the Reynolds number. Spheres and cylinders showed the most promise. The anode swing for a steel cylinder 15 in. in diameter by 31 in. long was 23 degrees of arc, compared with six degrees for a 24 in. diameter lead sphere. The anode shape and material recommended was an 18 in. diameter cast steel sphere. This represented an engineering compromise between the best material hydraulically (24 in. diameterlead sphere), and the best material electrochemically (high silicon cast iron). The lead anode was eliminated due to excessive weight (3,150 pounds), and the cast iron anode was eliminated because it was not available in a spherical form. (Since then it has become available in small hemispheres.)

The rest of the design considerations were the anode conductor cable, anode hoist, and standard electrical components such as switches, rectifier, and control box. The anode conductor cable was to do double duty as a conductor and support for the anode. The cable also had to be capable of being reeled upon the drum of the hoist.

The rectifier installed is a 12 volt, 120 ampere dc output operating from 155 volts ac. The rectifier stacks are oil-immersed. The anode is an 18 in. diameter steel sphere operating around 90 ampere. The anode has a life in excess of one year. When it deteriorates to a sphere of six to eight in. in diameter, the anode is cut from the cable and a new one attached.

Following installation for the cathodic protection system on Tower No. 2, systems were designed and installed for Tower No. 3 and Tower No. 4. A completely different type of anode was used on Tower No. 4, due to different tower construction. Bracing between the legs would have caused shielding of the caissons from a centrally located anode. Therefore, three anode beds were installed on the ocean floor at a depth of 180 ft and away from the tower.

Tower No. 4 also had caissons which were to contain salt water at times and diesel oil at other times. A cathodic protection system was designed for the interior of the three caissons, with an electrode in each caisson to monitor this system. This was necessary since the interiors were unavailable for routine entrance. The currents, voltages, and electrode potentials are metered on a cathodic protection control board. The meters are read at regular intervals and logged. The system was placed in operation on Tower No. 4 in October 1957. An inspection by a diver in March 1959, during work on the bracing, revealed the metal was in excellent shape although marine organisms were present on the surface. Tower No. 4, because of its greater amount of metal in the water, requires around 175 amperes of current for protection. The anodes used are high silicon cast iron, 3 in. in diameter and 60 ft long.

The protection from corrosion of these valuable structures in an environment which has no pity on metals is a definite success. The experience gained will be of great value in the design of all future underwater structures.★

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u e people and employment

The appointment of **James R. Weiner** as vice president-engineering for Philco Corp's Government and Industrial Group has been announced. Before joining Philco, **Mr. Weiner** was associate director of research and manager of the communications and control systems for the DISCOVERER, SAMOS, and MIDAS programs at Lockheed's Missiles and Space Div.

Marvin J. Bock has been named chief engineer of the Kearfott Div., General Precision Inc. **Mr. Bock** will also head up Microwave Products' R & D program. Prior to joining Kearfott, **Mr. Bock** was with the Raytheon Co.'s Santa Barbara Laboratory.

Data-Control Systems, Inc., has announced the appointment of **Roy W. Pyburn** as assistant to the president. **Mr. Pyburn** comes to DCS management - team from Ampex Corp., where he has been senior product planning engineer for the past four years.

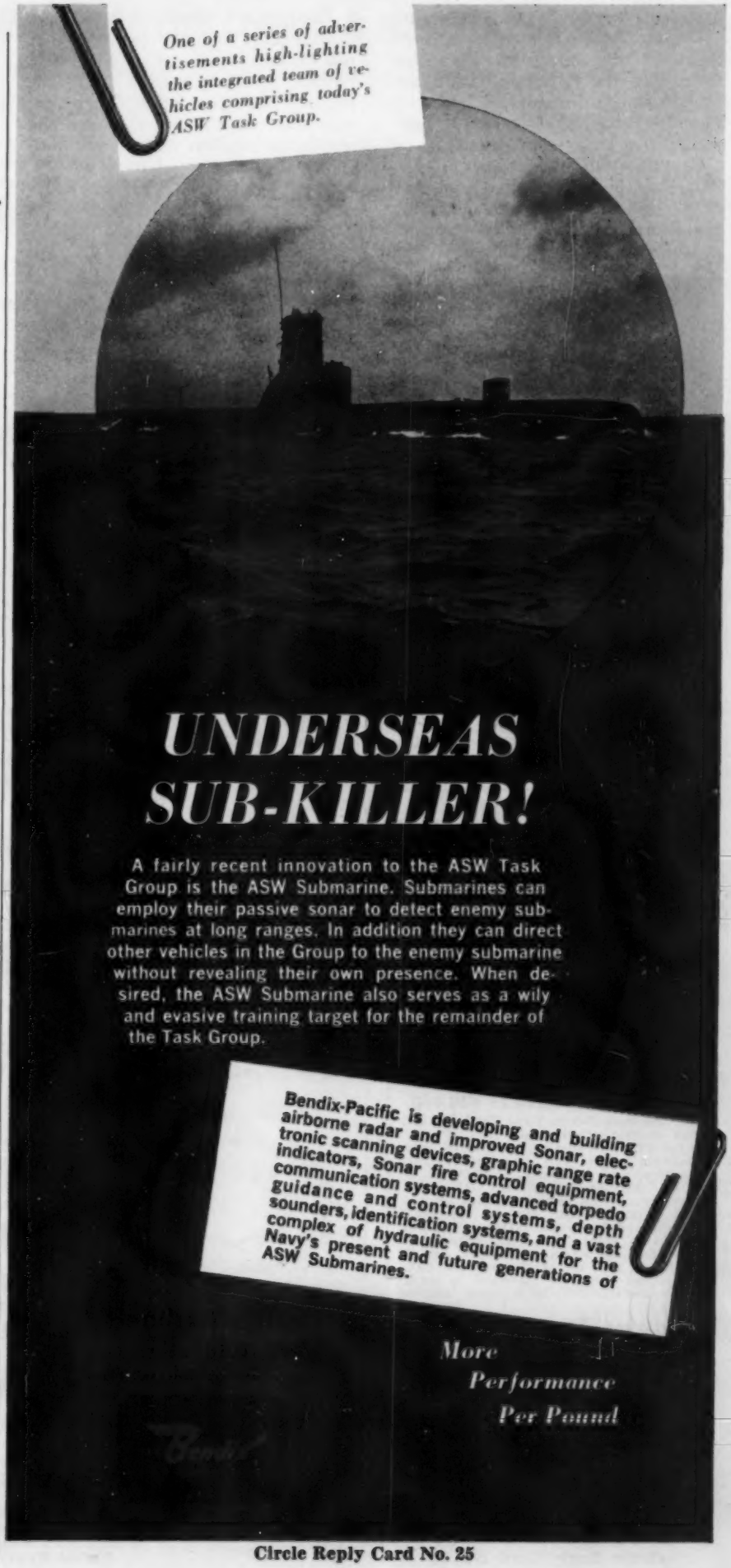
Howard A. Bond has been named vice president of systems and development in Dresser Electronics' SIE Div. From 1957 **Mr. Bond** was manager of reconnaissance systems at Stromberg-Carlson.

Louis R. Padberg, Jr., has been appointed scientific director of Emerson Electric Manufacturing Co.'s new Electronic Acoustic Research (EAR) Div. **Mr. Padberg,** an acoustic scientist, came to EAR from the U.S. Navy Electronics Laboratory in San Diego.

Stromberg-Carlson — San Diego — has appointed **L. H. Orpin** as general manager. **Mr. Orpin** will have full responsibility for all operations at the San Diego facilities.

Arnold M. Wolf, a veteran in the electronics field, has joined Specialty Electronics Development Corp. as general manager. **Mr. Wolf** was formerly vice president and general manager of the Engineering Products Div. of General Instrument Corp.'s Radio Receptor Div.

Servomechanisms / Inc. has announced the appointment of **Thomas H. Mansfield** to the position of chief engineer. **Mr. Mansfield** comes to the company from Hughes Aircraft Co.'s Guidance and Controls De-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partment, where he was manager.

Captain James B. Denton, former Head of the Electronic Warfare Branch in the Office of CNO, has been named director of Product Planning and Development of Servonics, Inc.

Captain William I. Bull (USN, Ret.) has been appointed assistant to the president for semiconductor operation, a newly created position, at Hoffman Electronics Corp.

WEINER

MANSFIELD

Captain Bull comes to Hoffman from the Navy, where he last served as the principal electronics officer for BuShips.

Industro Transistor Corp. has announced the appointment of **Edwin S. Davis** as device design engineer. Prior to joining Industro, **Mr. Davis** was supervisor of pilot engineering for CBS Electronics. **Mr. Davis** is located at Industro's Research & Development Center in Natick, Mass.

Lawrence Hermes, former vice president of General Devices, Inc., has become president of the International Communications Corp. The recently incorporated ICC will design and manufacture airborne and marine navigation and communication equipment.

Donald E. Wright is the new manager of stratetic communication for Electronics Operations at Ford Motor Co.'s Aeronutronics Div. **Mr. Wright** is the former manager of advanced electronics, Weapon Systems operations, at Aeronutronic.

McCOUBREY

HOLLOWAY

Bomac Laboratories, Inc. has announced the appointment of **Dr. Arthur O. McCoubrey** as manager of research and **Dr. Joseph H. Holloway** as manager, resonance physics research. **Dr. McCoubrey** has been associated with the development of TR and ATR microwave switches, microwave frequency reference cavities, and various applications of resonance physics including the frequency control work. **Dr. Holloway** was associated with the National Co. as section manager of the basic physics section before coming to Bomac.

Charles Liskey has been named executive assistant to the president of Electro-Tec Corp. **Mr. Liskey,** with Electro-Tec since 1952, has been plant manager of the Corp.'s Virginia Div. since 1958. His new assignment will take him to Electro-Tec's plant at Ormond Beach, Fla.

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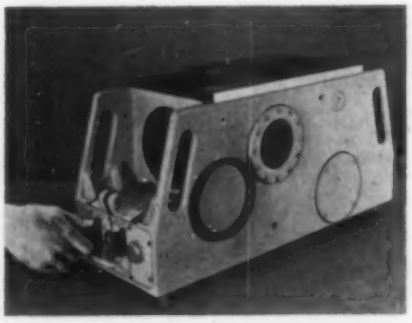
new u e products

Measuring Units for Polaris

Sensitive measuring equipment manufactured by Bausch and Lomb for General Electric's ordnance department has played an important role in the success of Navy's POLARIS. The equipment, known as the Azimuth Error Indicator (AEI), proved its accuracy in the recent series of successful launchings of the POLARIS from a submerged submarine.



The Azimuth Error Indicator performs a measuring function that permits the Azimuth mechanism in the missile's inertial guidance system to receive constant precise settings from the fire control system prior to launching.

The AEI is one of four key components manufactured by Bausch & Lomb which are mounted in nuclear-powered POLARIS submarines. The contents include an emergency periscope, alignment periscope and Penta Mirror Mark I.

Circle Reply Card No. 101

Temp Measuring System

A mercury-filled temperature measuring system available from the Bailey Meter Co. has a minimum capillary ambient temperature error and a wide range of span suppressions. Designated Class 4RD, the system is designed as a standard plug-in unit for the company's receiver-recorder.

The Bourdon tube element in the new system plugs into any of four positions in the recorder. Plain or coiled bulbs sense temperatures from minus 39 degrees to plus 1200 degrees F, and transmit them to the Bourdon tube along capillaries up to 200 feet long. Capillary ambient temperature error is limited to approximately 0.5 per cent per 200 degrees F per 100 ft. The new system is compatible with other Bailey plug-in units which can be plugged into the receiver-recorder to measure pneumatic and electrical quantities or to control programs.

Circle Reply Card No. 102

Piloted Pneumatic Valve

The Marotta Valve Corp. has developed a two-way, two-position, magnetically operated valve (MV-175) which can be supplied N.C. or N.O., depending on the application.

Other optional features that are available include: a manual override, a visuhl valve position indicator that can be either mechanically or electrically operated, ac or dc power source, and ½ in. or ¾ in. fittings.

When the valve is used in submarine high pressure air-systems, it is supplied with a forged naval brass body. A light-weight ac coil with a full wave rectifier operates on 100-125 volts ac at 60-400 cps. The missile/aircraft version is housed in a forged aluminum body and operates on 18-30 volts ac.

Operating pressure of the MV-175 is 3000 psig. Proof pressure and burst pressure are 1.5 times and 3 times, respectively, of the operating pressure. Capacity for the 0.5-in. line size is based on a 0.490 in. equivalent sharp edge orifice and 0.600 for 0.75-in. line size. Line and ambient temperatures are —65 degrees F to + 160 degrees F. Weight varies according to the optional equipment used.

Circle Reply Card No. 108

Magnetic Tape Cleaner

A magnetic tape cleaner designed for the automatic cleaning of magnetic recording tape has been introduced by Computer-Measurements Company.

The cleaner, Unicorn Model T-7070, operates at high speed with complete safety. Speed is adjustable from 0-300 ft per minute, with automatic shut-off that leaves the machine threaded with leader for continuous operation. The unit uses only non-inflammable, non-explosive solvents.

Operation is completely automatic: once the tape is in place and the solvent tank filled, the cleaner automatically completes all operations

and without disturbing the information on the tape.

The cleaning action features special protection for valuable tapes by allowing only velvet cotton fibers to contact the tape surface. In addition, the solvent forms an effective fluid barrier between the scrubbing roller and the tape to prevent scratches or abrasions. Cleaners are available for 0.75 in., one in., and two in. tape.

Circle Reply Card No. 103

Throttle Positioner

A three-unit remote throttle positioning systems for remote marine, jet and automotive engine control, formerly manufactured only for the military, has been released to the industrial market by Lear, Inc.

The field-tested system consists of

a throttle quadrant, amplifier and servo and is designed for easy adaptability to any test cell configuration. At the control console, the throttle quadrant offers course or fine adjustment, a large, easy-to-read read-

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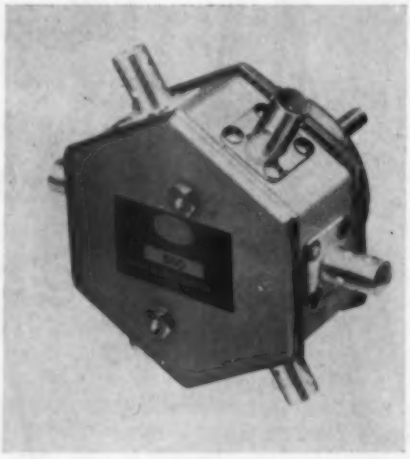
out dial, limit and idle stops, and a manual override switch for easy synchronization of control and servo. The tube-type amplifier uses standard components for simple maintenance.

Accuracy of positioning and proportional torque limiting are key features attributable to using the Lear magnetic particle clutch in the servo unit. Fast response and longevity also characterize the system.

Circle Reply Card No. 104

Coax Switches

The multi-position coax switches manufactured by Barker & Williamson, Inc., are now offered with BNC type connectors. They are designated as Models 560 and 561. Model 560 is a single pole, 5 position switch and provides contacts for switching to any one of five separate units such as transmitter, antenna, etc., and handles up to 350 volts RMS.



The 561 is a double-pole, 2 position unit for rapidly cutting equipment in and out of series connection in coaxial lines.

Both are designed for 52 and 75 ohm coaxial lines. Maximum cross talk — isolation between adjacent connectors — more than 48 db at 30 mc/s. Size across terminals is 4 in., and from front to back, including shaft, 3-9/16 in.

Circle Reply Card No. 105

A+ Semiconductor Equipment

Accurate temperature measurements of liquids at nearly any depth from a few feet to thousands of feet is now possible by means of long lead lengths developed for use with A+ Thermophil instruments.

These leads, available in any length, measure the various temperature layers that form when water, petroleum by-products, liquid chemicals and plastics and other fluids stratify. Through temperature differentials it is possible to pinpoint various strata or to maintain quality control and uniformity in a given fluid.

Temperature measurement errors due to probe lead length also are insignificant since the temperature sensing resistance bead has a very high impedance (several hundred thousand ohms), which changes rapidly with each degree of temperature variation.

The lead from the instrument is completely water-tight, oil-tight, and abrasion resistant. The probe is protected with a stainless steel protective guard against possible damage. The long probe leads are designed for use with any A+ Thermophil electronic thermometer covering temperatures between −148 degrees F and +554 degrees F.

Model No. 4416/4 is commonly used and indicates submerged temperatures to within +0.25 degrees F, and the range of this four scale instrument is from + 32 degrees F to +122 F. Response in liquids is extremely rapid — seven-tenths of a second time constant.

The power required for operation, consisting of standard dry cell batteries, is so small that new batteries are required only every six to eight months. Ac-powered models can be used with portable or fixed mount probes for continuous indication and recording if desired.

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Multi-polarized Antenna

A multi-polarized antenna which can do the work of four separate types of antennas in operating with missiles or space vehicles has been developed by the Electronics Div. of Chance Vought.

The highly-flexible unit will be used aboard the USNS *Range Tracker*, the Pacific Missile Range's first tracking vessel, which currently is being instrumented by Vought's Range Systems Div.

Vought Electronic's single antenna can be used with facilities for tracking, telemetering or command control of missiles or space vehicles. With its complete polarization coverage, it can perform the functions of four types of antennas — vertically polarized, horizontally polarized, and clockwise and counter-clockwise helical antennas.

With this one antenna it is possible to select the polarization best suited for operating with a particular missile or space vehicle, and polarization can be selected either through remote switching or automatically providing instant response.

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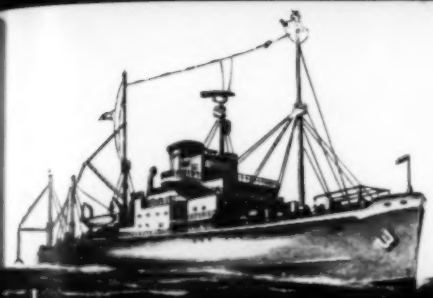
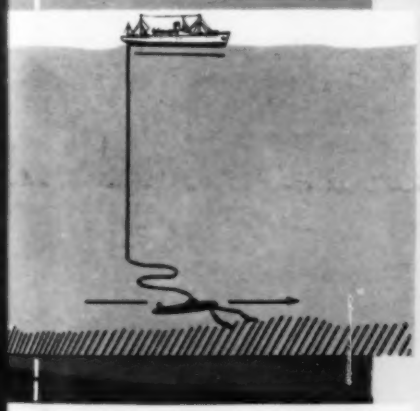


USI Reports on

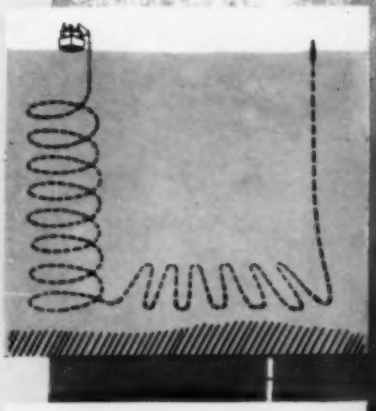
Five current projects on MECHANICAL EQUIPMENT for oceanographic research

***FOIF—Free Oceanographic Instrument Float.** Now undergoing deep sea testing, this float follows a free flight trajectory to the depths and return. By freeing the instrumentation from its connection to the mother ship, data gathering is far more efficient and faster.

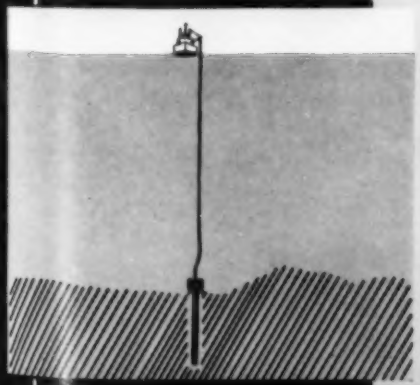


GRAPPLING SYSTEMS. A self contained, self propelled, remotely controlled grappling device for ocean floor work. Utilizing closed circuit television and light arrays, the oceanographer can search out and gather samples selectively with this mechanical hand. Also, suitable for attachment to bathyscaphes and deep diving submarines.

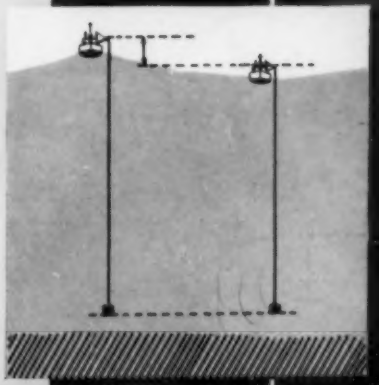
DUMS—DEEP UNMANNED SUBMERSIBLES. A new self propelled, deep diving unmanned submersible which follows a pre-set course to any depth for durations of four hours. Consisting of a fiber glass case and self contained jet drive power package, DUMS will collect data throughout large volumes of the ocean.



DEEP CORING DEVICE. Using a new principle in coring, this deep self powered corer can obtain long undisturbed cores of the basin sediments. Dropped freely, or cable lowered, the corer will level itself, collect a 200 ft. sample from one location in a vertical direction, and then return to the surface.



CONSTANT TENSION WINCHES. This research winch holds a constant tension in the cable thus eliminating tension and depth fluctuations caused by ship reaction to wave motion. By utilizing a new servo controlled hydrostatic drive, cable breakage and depth holding problems are minimized.



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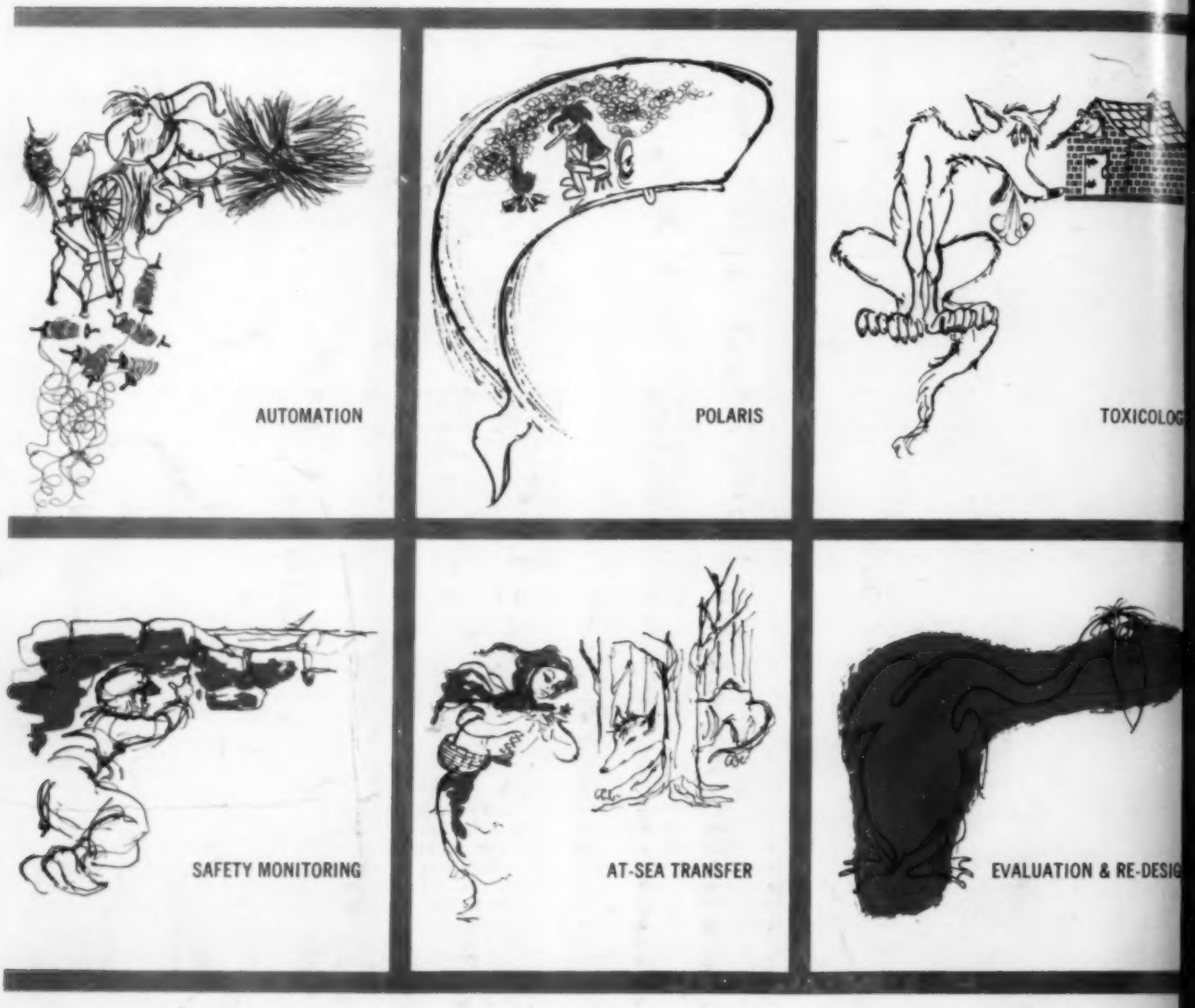

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